UNIVERSITY OF VERMONT

AND STATE AGRICULTURAL COLLEGE

EIGHTEENTH

ANNUAL REPORT

OF THE

VERMONT AGRICULTURAL

EXPERIMENT STATION

BURLINGTON, VT.

1904-1905

BURLINGTON:
FREE PRESS PRINTING CO.,
PRINTERS, BINDERS, STATIONERS,
1905.

THE VERMONT

Agricultural Experiment Station,

BURLINGTON, VT.

BOARD OF CONTROL

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L. R. JONES, Botanist.
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W. J. MORSE, Assistant Botanist.
F. M. HOLLISTER, Assistant Chemist.
MARY A. .BENSON, Stenographer.
E. H. POWELL, Treasurer.

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[1]Until February 1.

ANNOUNCEMENT

The "State Agricultural Experiment Station" was established in accordance with an act of the General Assembly of 1886, "for the promotion of scientific and practical agriculture in connection with and under the control of the University of Vermont and State Agricultural College." For the past eighteen years it has received the funds appropriated by Congress under the provisions of the act approved March 2, 1887. The State appropriation expired in 1890. An appropriation "not to exceed $1,000 annually" was made by the Legislature of 1898 for the purpose of printing the annual report, and one of $500 by the Legislature of 1902 to defray the expenses incurred in the inspection of feeding stuffs.

The Station is prepared to analyze and test fertilizers, feeding stuffs for domestic animals, seeds, milk and other agricultural materials and products—exclusive of water and human foods, which should be sent to the State board of health laboratory, Burlington,—to identify fruits, grasses, weeds, blights, insects, etc., and to give information on various subjects connected with agriculture for the use and benefit of the citizens of Vermont. The identification or analysis of minerals does not lie within the province of Station activities. Such samples and inquiries should be sent to the State geologist, Burlington.

All chemical analyses, etc., of agricultural materials proper to an Experiment station, that can be used for the public benefit, are made without charge, so far as time and means permit. The Station will undertake no work the results of which are not at its disposal to use or publish, if deemed advisable for the public good. The results of such analyses will be promptly communicated to the party sending the sample. Those that are of general interest are published.

It is the wish of the Board of Control to make the Station as widely useful as its resources will permit. Every Vermont citizen who is concerned in agriculture, whether farmer, manufacturer or dealer, has a right to apply to the Station for any assistance that comes within its province to render, and it will respond so far as lies in its power. All communications relating to agriculture, horticulture, plant or animal diseases, insects, etc., will be fairly considered, and, so far as possible, promptly answered.

The main station building is located on Main street at the south end of the college park. The farm and its buildings are on the Williston road, adjoining the University grounds on the east. Electric cars pass at Colchester avenue and University Place, within a third of a mile of the station building. Both the Station and the farm have telephone connections.

Instructions for taking samples of fertilizers, fodders, milk, seeds, etc., will be sent on application. Parties desiring to send samples should first write for these directions. Many samples received are useless, being incorrectly drawn. Parcels by express, to receive attention, should be prepaid and should bear the address of the shipper for purposes of identification.

Copies of the reports and bulletins of the Station are sent free of charge to any address on application.

Address all communications, not to individual officers, but to the

EXPERIMENT STATION, BURLINGTON, VT.

TABLE OF CONTENTS

OF BULLETINS 109-116, PAGES 1-244, PUBLISHED DURING THE YEAR BUT NOT INCLUDED IN THIS VOLUME

TABLE OF CONTENTS

OF EIGHTEENTH ANNUAL REPORT

FINANCIAL REPORT FOR THE FISCAL YEAR ENDING JUNE 30, 1905

Vermont Agricultural Experiment Station, in account with the United States Appropriation, 1904-1905.

DR.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1905, as per act of Congress approved March 2, 1887..............$15,000 00

CR.

	Abstract		
By Salaries	1	$7,169 27	
" Labor	2	3,170 89	
" Publications	3	669 02	
" Postage and stationery	4	469 31	
" Freight and express	5	35 88	
" Heat, light and water	6	501 53	
" Chemical supplies	7	145 09	
" Seeds, plants and sundry supplies	8	109 95	
" Fertilizers	9	140 39	
" Feeding stuffs	10	1,312 95	
" Library	11	87 92	
" Tools, implements and machinery	12	130 27	
" Furniture and fixtures	13	512 92	
" Scientific apparatus	14	131 33	
" Live stock	15	....	
" Traveling expenses	16	295 31	
" Contingent expenses	17	16 90	
" Building and repairs	18	101 07	
			$15,000 00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the Vermont Agricultural Experiment Station for the fiscal year ending June 30, 1905; that we have found the same well kept and classified as above, and that the receipts for the year from the treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000, for all of which proper vouchers are on file and have been by us examined and found correct.

And we further certify that the expenditures have been solely for the purposes set forth in the act of Congress approved March 2, 1887.

Signed,

{SEAL} MATTHEW H. BUCKHAM, CASSIUS PECK, GARDNER S. FASSETT, } Auditors.

Attest,

E. HENRY POWELL,
Custodian.

Receipts and disbursements under No. 83 of the Acts of 1902 (fertilizer law); No. 84 of the Acts of 1902 (feeding stuffs law); No. 81 of the Acts of 1898 (creamery inspection law); for the fiscal year ending June 30, 1905:

DR.

A. To license fees received from fertilizer companies and forwarded to State treasurer		$2,825 00
B. To State appropriation for feeding stuffs inspection	$500 00	
Add amount not drawn upon July 1, 1904	438 25	
		$ 938 25
C. To balance on hand last report	$ 9 39	
To receipts from applicants for licenses	42 00	
To receipts from supply houses, creameries and cheese factories for testing Babcock glassware	109 79	
		$ 161 18

CR.

	A.	B.	C.
By Salaries	$ 906 56	$157 50	....
" Labor	269 92	42 75	$140 25
" Publications	874 00	173 86	....
" Postage and stationery	45 47	....	....
" Freight and express	19 02	10 11	....
" Heat, light and water	57 30	....	2 29
" Sundry supplies	4 90	7 50	....
" Chemical supplies	224 79	....	1 50
" Traveling and sampling expenses	409 51	154 00	....
" Contingent expenses	12 97	....	5 26
Add amounts forwarded to State treasurer against which no expenditures were incurred prior to July 1, 1905	0.56	....	....
Add amount not drawn upon June 30, 1905	......	392 53	....
Add balance on hand unexpended	......	....	11 88
	$2,825 00	$938 25	$161 18

REPORT OF THE DIRECTOR

J. L. Hills

The present report covers the work of the Station during the past fiscal year, July 1, 1904, to June 30, 1905. The eight bulletins issued during that time, Nos. 109 to 116 inclusive, as well as the annual report, are both indexed in the latter on pages 248 and 249.

Publications

Eight bulletins and the seventeenth annual report, aggregating 472 pages of printed matter, have been issued during the year, the bulletins in editions of 12,000 to 15,000, the report in edition of 4,000. Abstracts of the regular bulletins appear on pages 260-263. A list of publications issued during the year follows:

1904.

September,	No. 109.	Commercial feeding stuffs, 8 pages.
December,	No. 110.	Commercial feeding stuffs, 12 pages.
December,	No. 111.	Abstract of seventeenth annual report, 48 pages.
April,	No. 112.	Commercial fertilizers, 24 pages.
April,	No. 113.	Preparation and use of sprays; spray calendar, 16 pages.
April,	No. 114.	Alfalfa in Vermont, 24 pages.
May,	No. 115.	Disease-resistant potatoes, 8 pages.
June,	No. 116.	Commercial fertilizers, 104 pages.

Many of the back bulletins and reports of the Station are nearly or quite out of print. Parties having spare copies of any of the publications noted in the following list would confer a favor by returning the same to the Station, thus enabling it the better to comply with requests from libraries and from other stations. Postage will be refunded to the sender on request.

All of the Station reports except the 3d, 13th, 16th and 17th, bulletins 1 to 20 inclusive (except 12 and 17) 22, 24, 25, 27 to 42 inclusive, 44, 47, 49 to 66 inclusive (except 52 and 58), 69 to 75 inclusive (except 73), 79, 81, 83 to 85 inclusive, 94, 100, 101, 104.

Publications on Hand

The Station has issued to the date of distributing this report, including the present number, 18 annual reports and 118 bulletins. Many of these are out of print. The following numbers are in print, and will be sent on request without charge as long as the supply lasts:

1888, April.	No. 12, Insecticides; seed tests; miscellaneous analyses	16 pages
November.	No. 13, Methods of cutting and planting potatoes; fertilizer analyses	12 pages
1889, October.	No. 17, Test of dairy cows at Vermont state fair	18 pages
1890, May.	No. 20, Analyses of commercial fertilizers	16 pages
September.	No. 21, A new milk test; testing milk at creameries and cheese factories; notes for the laboratory	32 pages
1891, March.	No. 23, Analyses of commercial fertilizers	16 pages
September.	No. 26, Maple sugar	24 pages
1893, May.	No. 35, Analyses of commercial fertilizers	16 pages
1894, May.	No. 41, Analyses of commercial fertilizers	16 pages
November.	No. 43, Household pests	8 pages
1895, March.	No. 45, Analyses of commercial fertilizers	8 pages
March.	No. 46, Analyses of commercial fertilizers	16 pages
May.	No. 47, Commercial fertilizers	40 pages
October.	No. 48, Gluten feeds and meals	20 pages
1896, April.	No. 51, Analyses of commercial fertilizers	12 pages
May.	No. 52, Analyses of commercial fertilizers	24 pages
August.	No. 53, The pollination of plums	20 pages
December.	No. 55, Apple growing in Grand Isle county	16 pages
1897, April.	No. 58, Analyses of commercial fertilizers	16 pages
November.	No. 61, Hardy apples for cold climates	16 pages
1898, April.	No. 64, Analyses of commercial fertilizers	16 pages
December.	No. 67, Hybrid plums	30 pages
1899, January.	No. 68, Inspection of milk tests and feeding stuffs	8 pages
April.	No. 70, Analyses of commercial fertilizers	16 pages
October.	No. 73, The trees of Vermont	54 pages
1900, March.	No. 76, The forest caterpillar	28 pages
April.	No. 77, Analyses of commercial fertilizers	24 pages
	No. 78, Analyses of commercial feeding stuffs	24 pages
May.	No. 80, Analyses of commercial fertilizers	48 pages
	No. 82, Analyses of commercial feeding stuffs	26 pages
1901, March.	No. 86, Analyses of commercial fertilizers	24 pages
	Thirteenth annual report (Potato diseases, weed killing, bacterial vegetable rots, plum propagation, plum and apple pollination, composition of potatoes and of artichokes, feeding trials with cows, food effect on butter quality, herd records).	258 pages
May.	No. 87, Analyses of commercial fertilizers	48 pages
October.	No. 88, Analyses of commercial feeding stuffs	16 pages
November.	No. 89, Plum culture	12 pages
December.	No. 90, Apple growing in Addison county	8 pages
1902, February.	No. 91, Analyses of commercial feeding stuffs	16 pages
April.	No. 92, Analyses of commercial fertilizers	24 pages
May.	No. 93, Commercial fertilizers	54 pages
May.	No. 94, Vermont grasses and clovers	48 pages
June.	No. 95, A poisonous plant—the common horsetail	8 pages
September.	No. 96, Apple pomace a good feed for cows	8 pages

	September.	No. 97, Analyses of commercial feeding stuffs....	16 pages
1903,	March.	No. 98, Analyses of commercial fertilizers........	24 pages
	May.	No. 99, Commercial fertilizers	88 pages
	October.	No. 102, The measurement of saw logs...........	8 pages
	December.	No. 103, The maple sap flow	160 pages
1904,	February.	No. 105, The maple sap flow....................	32 pages
		Sixteenth annual report .... (Plant diseases, potato maladies and their prevention, weeds, the shrubby cinquefoil, apple tree borers, mushrooms, fertilizer analyses, dairy husbandry, including feeding trials, herd records, etc.)	190 pages
	March.	No. 106, Abstract of sixteenth report............	48 pages
	April.	No. 107, Commercial fertilizers	24 pages
	June.	No. 108, Commercial fertilizers	68 pages
	September.	No. 109, Commercial feeding stuffs	8 pages
	December.	No. 110, Commercial feeding stuffs	12 pages
		Seventeenth annual report .... (Plant diseases, seed inspection, tomato growing, lettuce growing, bridge grafting, bordeaux mixture preparation, rhubarb forcing, maple sugar and syrup adulteration, dairy feeding, herd records).	228 pages
1905,	February.	No. 111, Abstract of seventeenth report.........	48 pages
	April.	No. 112, Commercial fertilizers	24 pages
	April.	No. 113, Preparation and use of sprays; spray calendar	16 pages
	April.	No. 114, Alfalfa in Vermont	24 pages
	May.	No. 115, Disease-resistant potatoes	8 pages
	June.	No. 116, Commercial fertilizers	104 pages
	October.	No. 117, Commercial feeding stuffs	8 pages
	December.	No. 118, Commercial feeding stuffs.......	8 pages

RELATION OF THE STATION TO THE PUBLIC

The Station seeks to promote the agricultural interests of Vermont in a five-fold manner:

1. By the scientific investigation of matters pertaining to agriculture and the publication of the results of its experimental work in the form of bulletins and reports, and also through the medium of the agricultural, scientific and general press.

2. By sampling, analyzing and reporting the quality of the sundry commercial fertilizers, feeding stuffs, etc., sold in Vermont, and by supervising certain matters relating to the conduct of the milk-test system at creameries and cheese factories.

3. By direct correspondence with individuals of all classes, particularly with farmers, and by the personal contact of members of the Station staff with the farming community at institutes, fairs, through visitation, etc.

4. By analyzing miscellaneous agricultural materials in accordance with section 263 of the Vermont statutes.

5. By so conducting its farming operations that visible and tangible evidence may be shown of the usefulness of science in agriculture; or, in other words, by affording daily object lessons in good modern farming.

1. *Publications.*—The determination and dissemination of new and useful facts of an agricultural bearing are main functions of the Station. It makes an attempt to reach its constituency in many ways, and it is felt that it is yearly becoming more useful. The passage of an act by the legislature of 1898 appropriating one thousand dollars annually for printing permits of a larger use of printer's ink than heretofore. For instance, such bulletins as 81 on the "Principles and Practice of Stock Feeding," 94 on "Vermont Grasses and Clovers," 100 on "Paying for Separator Cream at Creameries," and 113 on "Preparation and Use of Sprays," could hardly have been issued had it not been for this fund. The sum is a fair offset against expenses incurred in complying with section 263 V. S.

2. *Inspection work.*—This line of work serves in some degree to put the traffic in commercial fertilizers and feeding stuffs and the milk-testing practice of creameries and cheese factories on a higher plane. It is conducted under State laws.

3. *Correspondence.*—Considerable inroads upon the time of the director and of other members of the staff are made by the daily correspondence. It is, however, a legitimate line of service, which is helpful to the farmer, and is gladly undertaken. The personal contact of Station workers with the farmers is highly desirable. In few ways can the results of Station endeavors be brought home more directly to the farmer, or his needs and perplexities be more clearly realized by the scientist than by their meeting at the institute, in the field or by visitation. The director was an active member of the State board of agriculture for fourteen years, and Station representatives address from 20 to 30 farmers' institutes annually.

4. *Miscellaneous analytical work.*—Section 263 of the Vermont statutes requires the Station to analyze without charge materials of an agricultural nature. Parties intending to make use of the Station in this way are respectfully referred to the statements in the announcement on page 247. Attention is called to the fact that the Station no longer makes water analyses, a class of work now done at the laboratory of the State board of health. Mineral analyses, human food analyses (other than milk and milk products), the investigation of

cases of suspected poisoning, etc., are likewise outside its province. Questions concerning mineral resources should be sent to the State geologist, Prof. G. H. Perkins, Burlington; those having to do with poisoning should be referred to the State's attorney of the county in which the alleged poisoning occurred. Analyses of human food are made in the laboratory of the State board of health at Burlington.

5. *The Station farm.*—The farm and buildings are open to the inspection of all who may be interested therein. Visitors are welcome on week days to look over the buildings and stock. The kindly words of approval from thousands of visitors in the past show that the object lessons in good farming, the experiments which appeal to the eye, and the information elicited by direct questioning of those in charge alike prove helpful.

RELATION OF THE STATION TO THE STATE

The income of the Station is derived from several sources, including the congressional grant, State printing appropriation, license fees from commercial fertilizer companies, appropriation for feeding stuffs inspection, creamery glassware and operators' fees, and sale of farm produce. The financial reports showing the expenditures of several of these funds are printed on pages 250-251. It is to be noted that the State laws require the Station to do a class of work, which, while unquestionably of much value to the farming interests, is held by the government officials to be outside the province of the national enactment. Hence it is that the funds derived from the congressional grant cannot be used for such purposes and recourse must be had to other sources of income.

WORK OF THE YEAR

Full statements of the main results of Station endeavor during the past year published in this report (not in bulletins) in the departments of botany, horticulture, chemistry, and dairy husbandry make up the body of this report. Outlines of the general work of these departments with the titles of the articles giving page references are shown on the next three pages.

BOTANICAL DEPARTMENT

The articles contributed by the botanists, Professors Jones and Morse, appear under the following captions on pages 264-291 of this report:

Concerning disease-resistance of potatoes.[1] Pages 264-267.
The occurrence of plant diseases in Vermont in 1904. Pages 267-271.
Potato diseases and their remedies. Pages 272-291.

I. Results from spraying experiments. Pages 272-277.
II. Relation of date of digging to development of rot. Pages 277-279.
III. Relation of storage conditions to development of rot. Pages 279-284.
IV. Studies as to the time and method of tuber infection by the rot fungus. Pages 284-287.
V. Gaseous disinfection for potato scab. Pages 287-291.

Plant pathology continues to be the chief line of botanical study, although various other phases of economic botany are reviewed as opportunity admits. Potato maladies and the bacterial soft rot of vegetables have, as before, engaged a large share of attention.

HORTICULTURAL DEPARTMENT

The horticulturist's efforts during the past year have been directed mainly at the problem of disease-resistance of potatoes to late blight and rot. This work has been greatly enlarged over that of former years, in part owing to the coöperation of the Bureau of Plant Industry of the United States Department of Agriculture; but it is not sufficiently advanced at the present writing to justify further report than that hitherto issued in bulletin 115. Other lines of investigation the results of which are thought to be of sufficient importance to place on record are discussed by the horticulturist, Professor Stuart, under the following titles on pages 292-314 of this report:

Further studies in lettuce culture Pages 292-296.
Soil sterilization. Pages 297-299.
On the winter injury of apple trees. Pages 299-300.
Influence of stock on scion. Pages 300-305.
Miscellaneous fruit notes. Pages 305-309.
Insects of the year. Pages 309-314.

In the conduct of certain portions of this work the horticulturist has been very efficiently aided by the greenhouse and field assistant, Mr. C. H. Johnson.

CHEMICAL DEPARTMENT

The work of the chemists, Messrs. C. H. Jones and F. M. Hollister, includes the analyses of licensed commercial fertilizers (bulletins

[1] Summarized from U. S. Dept. Agr., Bu. Pl. Ind., Bul. 87 (1905) by L. R. Jones.

112 and 116) and of commercial feeding stuffs (bulletins 109 and 110), as well as the analytical work in connection with the feeding trials with dairy cattle discussed on pages 377-404 of this report. The usual miscellaneous samples from residents of the State have likewise been handled. The work for the Association of Official Agricultural Chemists was confined to the study of pure maple sugars and syrups, the object being to compare the individual work of different analysts and to formulate standards.

A beginning has been made of a study of the peat deposits of Vermont by Mr. Hollister. The more important deposits have been viewed, samples secured and analyses are under way.

A total of 4,821 samples have been handled during the year. They may be classified as follows: Milk (station herd) 2,820, milk and cream (from private individuals) 870, commercial fertilizers (official) 130, feeding stuffs (official) 322, maple syrup and sugar 127, coarse and fine feeds (feeding trials) 361, cattle feeds (from private individuals) 65, miscellaneous (from private individuals) 45, muck and peat (collected) 81.

The subject matter in this report contributed by the chemists appears on pages 315-340 under the following titles:

Maple syrup and maple sugar investigations with particular reference to the detection of adulteration; C. H. Jones, pages 315-339.

Miscellaneous analyses, C. H. Jones and F. M. Hollister, pages 339-340.

DAIRY HUSBANDRY

The dairy work of the past year, in immediate charge of the director, has followed closely the lines hitherto pursued, viz.: the conduct of somewhat extensive feeding trials with cows, the attempted measurement of the validity of the methods in current use in such trials, the maintenance of a herd record, etc. A beginning has been made upon a collation and digestion of the great mass of data which has accumulated in connection with the feeding of the dairy herd during the past decade, the first fruits of which appear in the main article under this heading. See pages 341-376.

The material which is in condition to justify publication appears under the following captions on pages 341-462;

ABSTRACTS OF BULLETINS

Copies of the bulletins abstracted in the following pages will be sent without charge to any address on application.

BULLETINS 109 AND 110, COMMERCIAL FEEDING STUFFS

J. L. HILLS, C. H. JONES and F. M. HOLLISTER

Several cottonseed meals were found to be under guaranty. Speaking broadly, the old process linseed meals ran above, and the new process ones below; while the gluten products, particularly the feeds, quite generally failed to meet the guaranty statements. The distillers' grains also were with but a single exception short of guaranty. The oat and corn and oat feeds were sometimes up and sometimes down. A few cases of provender sales contrary to law were found. The wheat offals of the fall inspection of 1904 were exceptionally low in protein, a situation which seems mainly brought about by the poor quality of the wheat crop.

BULLETIN 111, ABSTRACT OF SEVENTEENTH ANNUAL REPORT

J. L. HILLS

This bulletin, an abstract of the seventeenth annual report, a volume of about 225 pages, contains statements concerning plant diseases, potato maladies and their prevention, seed inspection, tomato, lettuce and rhubarb growing, bridge-grafting, bordeaux mixture making, maple sugar adulteration, fertilizer analyses, and dairy husbandry, including feeding trials, herd records, etc. The matter having to do with plant diseases and seeds is abstracted from the report of the botanists, L. R. Jones and W. J. Morse; the vegetable growing, grafting and bordeaux articles are briefed from the horticulturist's report by William Stuart; the statements as to maple adulterations and fertilizers are from the pen of the chemist, C. H. Jones; while the dairy husbandry matter was the work of the director, J. L. Hills. No abstract is given, as such would prove either inadequate or overlong.

BULLETIN 113—PREPARATION AND USE OF SPRAYS

WILLIAM STUART

A presentation of simple, concise and up-to-date directions for controlling the commoner diseases and insects attacking Vermont crops, by the use of fungicides, insecticides or other preventive measures. The conciseness of the directions is such as to make their summarization within small limits impossible.

BULLETIN 114—ALFALFA IN VERMONT

J. L. HILLS and L. R. JONES

Alfalfa is a plant of the clover family, larger, longer lived and in many ways superior to the common clovers.

It is richer in digestible protein and a better soil and manure pile enricher than in any other plant of economic importance. It is well adapted for use as hay, silage or a soiling crop and in some sections for pasture.

It is mainly grown west of the Mississippi and south of the Minnesota-Dakota line, but of late has been increasingly grown in such northern latitudes as Minnesota, Wisconsin and Canada.

Practically no success has been met with this crop in New England outside of Vermont. In Quebec, Ontario and Northern and Central New York it has succeeded at several points.

The results of 56 trials at as many Vermont points are summarized as permanent successes, 12; temporary successes, 10; success at outset, 8; seeming success, 5; questionable, 7; failure, 14. Thirty-six percent of the trials may fairly be said to have been a success, and 68 percent of these were located in the Champlain valley. Only 10 of the 56 alfalfa growers appear to have sown more than an acre. It should be noted that success with a fraction of an acre does not of necessity imply that an equal degree of success would be attained with plantings on larger areas. The preeminence of the Champlain valley in alfalfa growing seems to be due to the character of the farming in that section and to the nature of its soil.

Failures may generally be ascribed to one or more of several unfavorable soil or weather conditions, to weeds, to disease or to seed which either is inferior or from an unsuitable source. Suggestions are offered as to means of combatting these difficulties and the collection of home grown seed is commended.

BULLETIN 115—DISEASE RESISTANT POTATOES

WILLIAM STUART

While the data in hand does not warrant broad generalizations, yet the following inferences may be drawn:

(1) Some varieties are less subject to vine injury than others.

(2) Some show a greater tuber resistance to rot than others.

(3) With some there seems to be a fairly close relation between resistance of vine to disease and the tuber to rot.

(4) Selection has not given visible increase of resistance.

Hybridization and the growing of seedling plants followed by careful selection seem to offer a more logical method of securing disease-resistant varieties than does selection.

BULLETINS 112 AND 116—COMMERCIAL FERTILIZERS

J. L. HILLS, C. H. JONES and F. M. HOLLISTER

Results of inspection.—The Station drew from dealers' stocks and analyzed 130 of the 137 licensed brands, the output of 13 companies, all 1905 goods.

Quantity of plant food.—Only 71 percent of the brands met their guaranties. Seven brands failed to afford a commercial equivalent of their promises. One brand was found to be far below its guaranty statement. The average fertilizer carried eight percent more plant food than it was said to contain. Its composition is essentially the same this year that it was in 1904.

Quality of plant food.—The quality of the crude stock used in manufacturing the goods was found on the whole to be all that could be wished. A few criticisms, however, may be made. Nearly one-half of the brands, mostly the low grade and low priced goods, carried no water-soluble nitrogen. An inferential claim, that sulphate of potash was used, appears on two-thirds of the brands; it was actually used in but a sixth of them. The organic nitrogen used, with possibly one or two exceptions, seems to have been of good quality.

Selling prices and valuations.—The average selling price was $29.62; the average valuation, $19.04. One dollar in three spent for mixed fertilizers was paid to the manufacturer, railroad, and selling agent for their work, while only two of the three paid for plant food. But 56 cents' worth of plant food was bought for a dollar in average low grade goods, and 64 cents' worth in medium grade goods. The average high grade brand, however, afforded 73 cents' worth for a

dollar. Some Vermont buyers paid twice as much for plant food as did others.

How, when and what to buy are discussed, systems of fertilization, methods of application, and the kinds of plant food best fitted for sundry purposes are outlined and eighty formulas for all sorts and conditions of crops, with suggestions as to their use, are offered.

The analyses of the fertilizers sold in Vermont in 1905 appear on pages 222-232 of the bulletin.

A comparison of analyses of brands for five years shows in some cases essential evenness and in others considerable variation in composition. The tables showing composition for five years should prove helpful to the early buyer of mixed goods.

CONCERNING DISEASE RESISTANCE OF POTATOES

L. R. JONES

A considerable part of the time of the writer has been given to the preparation of a report upon potato diseases, with special reference to disease-resistance of varieties. This is the outcome of several months spent in a visit to the chief potato growing sections of Europe, supplemented by inquiries in America. It was undertaken in cooperation with the Bureau of Plant Industry, United States Department of Agriculture, and has been just (December, 1905) issued from the press.[1]

Since this investigation is of general rather than local interest and will be available to such of the readers of this report as care to send to the Department for it, it does not seem wise to republish anything here except the following summary which is quoted from the close of the bulletin cited:

From the nature of this bulletin it is not practicable to summarize all parts consistently. The following points are those of chief practical interest:

The aim of the bulletin is to present in concise form what is known about disease-resistance in potatoes. Much of this information is from European sources.

Certain minor diseases of obscure nature, but apparently non-parasitic are first considered,—internal brown spot, filosité and leaf spot. Among other remedial measures for each is that of selection of resistant varieties.

Scab-diseases of tubers are in most cases, and perhaps in all of parasitic origin, fungus or bacterial. Apparently the variety of these is greater in Europe than in America, but the severity is less there. It is undecided to what extent the American type of scab occurs in Europe, so a close comparison of conditions and remedies is not practicable. In Germany certain varieties are known to be more scab-resistant than are others, among them being Richter's Imperator, Professor Wohltmann and Irene. The same is true in America, White Beauty leading the list so far as known. Other American varieties showing a considerable degree of resistance are Carmen No. 3, American Giant, Sir Walter Raleigh and Irish Cobbler. Scab Proof and Aurora are also highly commended for scab-resistance.

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[1]Jones, L. R., Disease Resistance of Potatoes, U. S. Dept. Agr., Bu. Pl. Ind., Bul. 87 (1905).

Various stem-diseases of the potato are known. The commonest type in Europe is termed Black-leg (Schwarzbeinigkeit) a bacterial disease. It is not known to occur in America, but it resembles certain maladies which do occur here and which are as yet imperfectly understood. Varietal resistance to black-leg is not fully established, but apparently Dabersche and certain similar thick-skinned starch-rich late varieties are more resistant than thin-skinned starch-poor early varieties of the Rose type. Factor and Up-to-date showed a considerable degree of resistance to black-leg in England. La Czarine and other varieties are reported to show resistance to a bacterial stem disease in France.

The late blight and rot due to the fungus *Phytophthora infestans* occurs more commonly in Europe than in America. Attention has been given for many years to relative varietal susceptibility to this disease, especially in Great Britain and Germany. Varieties of superior disease-resistance are known in both countries and a number of the most promising from these and other European sources have been imported for trial.

The following statements are tentatively formulated as to the nature of resistance toward blight and rot and the characters of the varieties exhibiting it:

1. Disease-resistence in potatoes is relative, not absolute, no variety known being wholly proof against late blight and rot.

2. It seems related to general vegetative vigor and is therefore in a measure dependent upon cultural and developmental conditions and tends to decrease with the age of the variety.

3. It can be restored by originating new varieties from seed, especially if of hybrid origin. Not all seedlings show superior disease-resistance.

4. The use of other species of tuber-bearing Solanums for hybridizing offers some promise, but no practical results have yet been secured.

5. Possibly the disease-resistance in established varieties can be improved by selection, but this has not been proved.

6. Early varieties may escape the disease by maturing before it becomes epidemic, but when similarly exposed they are as a class less resistant than late varieties.

7. The source of seed-tubers is a matter of importance, northern-grown seed giving plants of superior disease resistance in Europe. Seed from a crop that was not too highly fertilized is probably preferable. Possibly tubers are better for seed purposes if dug before they reach full maturity.

8. High fertilization, especially with nitrogenous manures, lowers the power of the plants to resist both blight and rot.

9. Varieties relatively rich in starch are more resistant to rot and those richer in nitrogen are more susceptible to it.

10. So far as skin characters are an index the thicker rough-skinned red varieties seem more resistant as a class than the thin-skin white varieties.

11. So far as stem and foliage characters are concerned the evidence favors a stem that is hard, rough and rather woody at the base and small, somewhat rough and dark-colored leaves.

The varieties rated highest as to disease-resistance in England are: Evergood, Discovery, Royal Kidney, Northern Star, Sir John Llewelyn, King Edward VII, Eldorado, Factor.

In Germany and Holland the following represent the best types: Mohort, Irene, Geheimrat Thiel, Professor Wohltmann, Boncza, Eigenheimer, Paul Krüger.

In Belgium and France no improvement as to disease-resistance has been made over the best English and German types.

In America trials as to disease-resistance have been conducted at some of the Experiment stations, notably in Vermont, where experiments in breeding and selection for increased resistance are under way.

Their results have been correlated with information recently secured by a circular of inquiry addressed to a large number of potato specialists in the northeastern states and Canada. From these it appears that a wide variation is shown in disease-resistance among the varieties now in cultivation, but that no one variety is preeminent. Among those which have been rather widely tested, the following deserve mention as of the resistant class: Dakota Red, Rust Proof, Irish Cobbler, Sir Walter Raleigh, Doe's Pride, White Beauty. Certain European varieties of the disease-resisting type seem to hold that character as grown in this country, e. g. Professor Maerker and Sutton's Discovery. There is much of promise in certain new varieties under trial at the Vermont Station. Several sorts of reputed disease-resistance have recently been placed on the market by American seedsmen, e. g. Harris' Snowball, Dibble's Ionia Seedling, Burpee's Vermont Gold Coin, Johnson's Norcross, Star of the East and Babbitt. Those having opportunity should carefully observe the relative disease-resistance of these and also of other new varieties.

The evidence at hand seems to justify the hope that the combined efforts of potato specialists working from both the practical and scientific standpoints, may result soon in the development of varieties of potatoes, combining general excellence with a high degree of disease-

resistance. All who can do so are urged to aid toward the accomplishment of this end.

THE OCCURRENCE OF PLANT DISEASES IN VERMONT IN 1904

L. R. JONES and W. J. MORSE

The close relationship between plant diseases and weather conditions was noted in the last report. In order to give a basis for continued comparison the following record for the year is inserted, based on data furnished by Messrs. W. B. Gates, observer at Burlington, and W. A. Shaw, observer at Northfield, for the Weather Bureau of the United States Department of Agriculture:

	Mean temperature	Mean temperature for * years	Total rainfall	Average total rainfall for * years	Number clear days	Number cloudy days	Number partly cloudy days
Burlington—							
May,	56.5	58.5	2.58	3.10	12	7	12
June,	63.7	67.6	4.70	3.42	9	8	13
July,	70.0	71.4	7.67	4.08	10	6	15
August,	66.0	68.6	3.98	4.14	12	4	15
September,	60.7	61.7	4.32	3.62	9	12	9
Northfield—							
May,	52	53	1.74	2.10	4	11	16
June,	59	62	3.89	3.16	4	13	13
July,	66	66	6.17	3.72	2	9	20
August,	61	63	4.02	2.40	12	10	9
September,	55	56	4.35	2.91	7	12	11

*Burlington, 22 years; Northfield, 19 years.

The results of these conditions were a vigorous development of agricultural crops in general and, with a few exceptions, a relative freedom from disease.

ORCHARD CROPS

The apple and pear diseases of chief importance in this region are scab (*Venturia*) and blight (*Bacillus amylovorus*). Neither of these maladies has done serious harm since the remarkable spring drought of 1903, which evidently almost exterminated these parasites from Vermont orchards. Except for this fact there could hardly have failed to be considerable scab the past season. As it was there was only a

moderate development of this fungus and small loss, despite the fact that less than the usual amount of orchard spraying was done. There was more scab than in 1904, however, and in the writer's judgment there is a sufficient reestablishment of the fungus in most Vermont orchards to augur serious damage from it another year, providing weather conditions favor. The renewai of spraying operations where they have been held in abeyance the past two seasons is therefore to be urged. The same general statements will apply as to the occurrence of the blight. Less than usual has been observed since the drought but enough was seen this summer to start the epidemic next year if climatic conditions favor.

The injuries resulting from the winter killing of 1903-04 were still in evidence this summer, many of the trees which recovered showing but weakly growth. In one such case, examined in August, 1905, it was found that most of the wood of the preceding year was brown and dead, although the cambium had survived and given a weakly growth during the last summer.

The cherry and plum crops were heavier than common in 1905. The brown rot (*Monilia*) made its appearance unusually early, attacking the fruit spurs of the sweet cherry in some cases before the flowers were fully faded. It continued to develop persistently on the sweet cherries and, later, on the more susceptible varieties of plums, destroying not only the young fruits but killing the fruiting twigs back to the main branches. Probably the average loss amounted to from 10 to 25 percent of the crop. Extra precautions should be taken this winter to clean out such orchards.

GARDEN CROPS

No maladies of peculiar interest were observed on garden crops other than the potato. Some cases of bacterial soft rots of vegetables came to our notice. In one of these, turnips were growing alongside rutabagas. The former rotted badly, while the latter showed none of the trouble, indicating clearly a relatively greater liability of turnips to the disease. The Station horticulturist observed a similar bacterial rot of the tap-root of parsley. This was growing in soil where turnips rotted badly last year, and is strong evidence that these diseases are perpetuated from crop to crop in garden soils. The increasing number of reports of club-root of cabbage and allied crops indicate that the germs of this disease are being more widely scattered year by year. Where one values his soil for the production of these cruciferous crops he should be cautious about setting purchased cabbage plants unless

he knows them to be from soil free of the disease. It is believed that much new infection has occurred in this way in Vermont during recent years.

POTATO DISEASES

The climatic conditions of the summer of 1905 were in general favorable for the potato crop until September.

Tip-burn.—Tip-burn did only a moderate amount of damage, less than it ordinarily does.

Early blight.—There was less early blight (*Alternaria solani*) than usual, except on light soils. On these it developed destructively throughout August and early September and materially shortened the life of the plants, as will be shown in detail later in this report.

Late blight and rot.—The amount of rot which occurred in 1904 made the recurrence of the late blight in 1905 a certainty, provided climatic conditions favored. Until the latter part of August such conditions were not generally present. This blight was first observed on potato leaves August 13. Thereafter it spread but slowly for some time. Examinations of numerous fields made August 23 showed that the fungus occurred in practically all of them, but it was not as yet conspicuously destructive anywhere, early blight being much more in evidence at that date. During the last week of August, however, it spread persistently, but did not become generally conspicuous until the first week of September. This week was warm with frequent gentle rains and the foliage on all except favorably situated or resistant varieties rapidly blackened and was soon practically ruined. The weather continued sufficiently rainy for two weeks thereafter to afford ideal conditions for the rot and the resultant loss was exceptionally great, many fields on low or heavy soil not being worth the digging. That this is in considerable degree unnecessary is shown later in this report.

The opportunity which the senior writer enjoyed of observing the potato maladies of Europe in 1904 gave him a special incentive for keeping a close watch for the occurrence of any of these in the fields here under observation in 1905. Particular attention was given to the following:

Black leg, the *Schwarzbeinigkeit* of the Germans, is a well-marked potato disease common in Europe, characterized by a soft rot of the base of the stem. Nothing of this was seen here. Neither was there any evidence in our fields of the similar rosette disease, which Selby has described as associated with the common *Rhizoctonia* of the potato. The latter fungus is common as a surface saprophyte

upon potato tubers, forming black flecks and creeping over the underground surface of the bases of the stems. Evidence of the fact that it is essentially a surface saprophyte was observed when the stalk was cut from vigorous young potato plants about the middle of July. One of the stumps protruded some three inches above the surface of the soil. This was seen on July 24 to be covered with a white fungus growth for two inches above the soil and examination showed it to be a basidiomycetous fungus, believed to be *Corticium vagum* var. *solani*, Burt, the fruiting stage of the Rhizoctonia. The tip of the stump showed a bacterial soft rot, but the stem tissues underneath the fungus were hard and green, the fungus growth apparently being incapable of causing serious lesion even when developed thus abundantly and upon weakened tissues.

Leaf spot diseases.—Two leaf spot diseases of minor importance were observed for the first time. The first of these began to show upon two separate hills in one of the experimental fields early in July. One of these was of the Boss, the other of the Snow variety. The appearance of small black spots on the leaves suggested early blight at first glance, but upon closer observation it was seen that as a rule the blackening began on the underside of the veinlets and spread more rapidly along the veins than laterally. No fungus which could account for this spotting was detected on these plants then or at any time during the next four weeks, during which their development was kept under observation. One hill was dug up July 18, when the seed tuber, root system and stem bases seemed sound. The other was kept under observation till its death about September first. The spots gradually enlarged, bearing a close resemblance to early blight but continuing sterile; nor was the true early blight seen upon this or any adjacent plants. The older leaves gradually died and the spotting appeared on the younger leaves from the time of their unfolding during August. It was in our judgment a non-parasitic malady involving the plant as a whole, the local spotting of the leaves being merely the symptom. This is undoubtedly the same trouble that was seen by the senior writer in Germany and also in England, and called by Dr. Sorauer "Flecken necrosis." A discussion of this malady has already been given in more detail in the departmental bulletin hitherto cited (foot note page —). Suffice it to add here that it was not seen upon any other hills of these varieties or on any of the large number of other varieties under trial at this Station, including many from Europe as well as from America. A similar malady was, however, common on the Mexican *Solanum polyadenium* in the horticulturist's potato collection.

Another disease unrecorded in America so far as can be learned, and certainly never seen by the writers, appeared in a potato field under observation this year. It was first seen on an early planted piece of Early Rose potatoes. Obscurely defined pale yellowish spots, one-eighth to one-fourth of an inch in diameter were seen upon the lower leaves of many of the plants when in early blossom about the first of July. The lower surface of these spots was covered with a delicate gray growth, which the microscope showed to be the richly fruiting threads of a fungus, evidently a *Cercospora*. These spots increased in number and somewhat in size during the next two weeks, so that by July 15 most of the leaves on the lower half of the plants showed the spots, and some spots were appearing on the upper leaves. These began on the leaves while they were of a normal green color, indicating that the fungus is parasitic, but of the class of weakling parasites, i. e. it attacks only the foliage which is declining in vigor. In the gross appearance of the spots and in its occurrence and destructiveness it was much like *Cladosporium fulvum*, which was developing at this same season on the leaves of neighboring tomato plants. In the later stages of its development the fungus growth was often apparent on the upper side of the leaf as well as upon the lower. In some cases the invaded spots blackened and died while the rest of the leaves remained green. More usually, however, the entire leaf slowly yellowed and shrivelled. This spotting spread during July over an unknown variety of potato immediately adjacent to the Early Rose, and in August and September a slight development occurred upon several other varieties of later potatoes which were a few rods removed from these. It caused a considerable damage from hastening the death of the vines of the earlier potatoes. There was no way of measuring this loss, as it was uniformly distributed over the piece, but it was estimated as equivalent to a mild attack of early blight and reduced the yield by perhaps one-fourth. It did no harm of practical consequence on the later varieties.

The fungus is now being studied in the laboratory and a later publication will probably deal with its specific and cultural characters.

POTATO DISEASES AND THEIR REMEDIES

L. R. JONES and W. J. MORSE

I. RESULTS FROM SPRAYING EXPERIMENTS

SPRAYING THE VINES FOR LATE BLIGHT AND ROT

The potato field chosen for the spraying experiments against late blight and rot in 1905 was planted the middle of May with Delawares. The soil was a gravelly loam in good fertility, well drained and excellently adapted for potatoes.

Twenty-four rows were staked off for the experimental work, the balance being sprayed in connection with the regular farm operations. These twenty-four rows were divided into four plots of six rows each. Plots 1 and 3 were sprayed alike with bordeaux mixture, plots 2 and 4 being left as controls and treated only with paris green in lime to ward off insect injuries.

The bordeaux mixture used consisted of 6 pounds of copper sulphate, 4 pounds of lime and 40 gallons of water, with the addition of one-half pound of paris green. Two applications of this mixture were made on August 2 and 21, respectively. The first traces of the late blight fungus were seen on the leaves of the control rows August 13. It spread but slowly until about September first. Thereafter, being favored by moist warm weather it worked rapidly over these rows, soon destroying the tops. The sprayed plants held their foliage well through September. The plots were dug and sorted October 13. The outside rows of each plot were rejected to insure greater accuracy. The results as shown by the remaining rows are as follows, expressed in bushels per acre:

Plot	Treatment	Yield sound	Rotten
I.	Bordeaux mixture,	342	8
II.	No fungicide,	191	46
III.	Bordeaux mixture,	422	4
IV.	No fungicide,	232	66
	Average where sprayed,	382	6
	Average where not sprayed,	221	56
	Gain from spraying,	161	

It is evident from these figures that as heretofore there was a large gain from the use of bordeaux mixture. These results are in agreement with those extending now over fifteen successive years. We have always found spraying a profitable procedure with early potatoes because of its effect in warding off insect attacks and early blight, aside from the general stimulation it affords to the plants. Evidence on these points secured this season is presented later in this

report, page 275. But the greatest gains have always been found with the later crop, i. e. vigorous main crop varieties planted in May and maturing in the autumn. The following table fairly presents the results obtained during fifteen years and furnishes such conclusive evidence as ought to impress potato growers of this section with the idea that *proper spraying pays.*

GAINS FROM USE OF BORDEAUX MIXTURE ON LATE POTATOES

Variety	Planted	Sprayed	Yield per acre where sprayed	Yield per acre where not sprayed	Gain per acre
White Star	May —, 1891	Aug. 26, Sept. 8	313 bu.	248 bu	65 bu.
" "	May 20, 1892	July 30, Aug. 13, 25	291 "	99 "	192 "
" "	May 20, 1893	Aug. 1, 16, 29	338 "	114 "	224 "
" "	Apr. 26, 1894	June 16, July 17, Aug. 30	323 "	251 "	72 "
" "	May 20, 1895	July 25, Aug. 13, 31	389 "	219 "	170 "
Polaris	May 15, 1896	Aug. 7, 21	325 "	257 "	68 "
"	June 1, 1897	July 27, Aug. 17, 28	151 "	80 "	71 "
White Star	May 10, 1898	July 21, Aug. 10	238 "	112 "	126 "
Average, 3 varieties	May 18, 1899	July 26, Aug. 17, Sept. 8	229 "	161 "	68 "
Delaware	May 23, 1900	Aug. 4, 23	285 "	225 "	60 "
"	May 25, 1901	July 20, Aug. 21	170 "	54 "	116 "
"	May 15, 1902	Aug. 1, 20	298 "	164 "	134"
Green Mtn.	May 1, 1903	Aug. 10	361 "	237 "	124 "
Delaware	May 25, 1904	Aug. 1, Sept. 1	327 "	193 "	134 "
"	May 15, 1905	Aug. 2, 21	382 "	221 "	161 "
Average of 15 years			295 "	176 "	119 "

SPRAYING THE SOIL TO PREVENT THE ROT

Practically all of the potato rot which occurs in Vermont is due to the late blight fungus, and to the decay of the tubers which follows the development of the fungus on the foliage. Attention was called in a former report[1] to the controversy which often arises as to whether tuber infection is due to the passage of the fungus down the blighting stems or whether it results from the washing or migration of the spores through the soil. The publication referred to reports upon trials designed to throw light upon this matter by spraying the surface of the ground with bordeaux mixture. The trials were repeated in 1905.

Details of experiment.—Delaware potatoes were planted June 10 upon a heavy, moist clay loam, which had been well manured with the expectation of planting it to corn. Eight rows of these potatoes were selected for the trial. On August 2, before any signs of the late blight appeared on the leaves, the surface of the soil under four of these rows was thoroughly sprayed with bordeaux mixture, care being taken to get none of the mixture on the foliage. This procedure

[1]Vt. Sta. Rpt., 15, p. 218 (1902).

was repeated on August 18. Up to this time no late blight had been seen on these plants. It appeared soon after, however, and developed persistently and destructively throughout September, the foliage being practically all destroyed by it. Meanwhile, on August 28, a third and final spraying was made of the surface of the soil. Thus the soil under one-half of the plants was sprayed three times, with control rows untreated. No fungicide was applied to the foliage of any of the plants and the late blight was rampant on all alike. Since September was a rainy month and this clay soil especially favorable to rot, the conditions were ideal for a severe development of the disease in the tubers. The following figures show that such a development occurred. The tubers were dug on October 13, at which time there was but little life left in the tops. Since the four rows where the soil was sprayed adjoined the four unsprayed control rows, it seemed safer, in order to avoid possible cross contamination, to make use of the results afforded by the middle two rows only of either plot. The yields were as follows:

Soil sprayed. Sound tubers, 60.2 pounds; rotten tubers, 12.5 pounds.
No treatment. Sound tubers, 13.5 pounds; rotten tubers, 57.9 pounds.

Where no treatment was given, 81 percent rotted in the ground; where the soil was sprayed, only 17 percent rotted.

Discussion of results.—The data obtained in the similar trial of 1902, already referred to, are pertinent here. The disease was not as severe then, but the outcome was as follows:

Soil sprayed. Sound tubers, 151 pounds; rotten tubers, 2.5 pounds.
No treatment. Sound tubers, 113 pounds; rotten tubers, 26 pounds.

When reduced to percents the 1902 results show 19 percent of rot where the soil was not sprayed as compared with 2 percent where it was sprayed.

The results of the two trials are in general agreement, therefore, in showing not only that the disease passes from leaf to tuber, but that the main channel at least is through the soil rather than through the stem. This is in accord with the explanation of the habits of the fungus generally accepted by botanists, viz., that the tubers rot because of infection by spores developed on the foliage and thence finding their way through the soil, largely by being washed there by rains. The fact that there was considerable rot this year in spite of the spraying appears to contradict the claim that *all* of the tuber infection is to be thus explained. Observations which are to be discussed later (page 285) lead to the conclusion that there is some spread of the fungus from tuber to tuber in the soil. The conditions were favorable for this in the above experiment of 1905, but not so in 1902, and

the difference in results is probably largely due to this fact. While soil spraying is not to be recommended in practice, it may be noted that in the later sprayings when the disease is bad and soil heavy it may pay to make extra heavy applications of the mixture, that enough may reach the surface of the soil to check the development of the fungus spores falling thereon.

SPRAYING AS A REMEDY FOR EARLY BLIGHT

The climatic conditions during the growing season of 1905 were in general sufficiently moist and cool to be generally favorable to the development of the potato, especially during the latter part of the summer. This resulted in less than the usual amount of early blight (*Alternaria solani*), which is a disease characteristic of hot, dry weather. The only exception observed was on the experimental field situated on the sand plain farm belonging to the University. The 1904 crop on this piece was practically a failure owing to early blight. Foreseeing a probable repetition of the trouble on the same field this year, a spraying experiment was planned to determine how far bordeaux mixture will check the disease under these conditions. While evidence has been secured in previous years that it will do so in some measure, difficulty has been experienced in formulating exact conclusions because of the usual complication of late blight or other troubles with the early blight.

Details of experiment.—The soil is a light sandy loam recently cleared from pitch pine, and planted with potatoes in 1904 as well as the present year. The crop was planted June 9 in drills 40 inches apart, 15 inches between sets. There were thirty-six rows altogether, each 60 feet long, consisting of six rows of each of the following varieties: Rural New Yorker No. 2, Delaware, Green Mountain, Polaris, Early Rose and Early Ohio.

It will be noted that this series includes a representative set of standard varieties, ranging in season from the earliest like Early Ohio to medium late like the first three. The conditions proved ideal for the test of the question proposed. Owing to the lateness of planting and the favorable summer, all varieties alike continued their growth until well into the autumn. Moreover, there was during the last six weeks of their life a typical and severe development of the early blight fungus upon the foliage, with practically no complication with other maladies such as late blight and tip-burn. The standard bordeaux-paris green mixture[1] was used on the sprayed rows and paris green

[1] 6 pounds copper sulphate, 4 pounds lime, 40 gallons water, ½ pound paris green. The control rows were dusted with one part paris green in 15 parts air slaked lime.

and lime applied to the control rows. Upon one-third of the rows, two of each variety, the bordeaux-paris green mixture was applied five times, July 15 and 24, August 2, 18 and 28. Upon another third, only three applications were made, the second and fourth being omitted. The other two rows left as controls received three applications of paris green and lime dusted upon the plants freely. This sufficed to keep them free from the larvae or young slugs of the potato beetle. Grasshoppers and mature potato beetles wrought some injury in September upon the unsprayed rows, while there was practically no damage done to the sprayed rows. This must be held in a minor way responsible for the difference in yield which will be explained later, but it does not in any way affect the validity of the conclusions as to the efficacy of bordeaux mixture as a remedy against the early blight fungus.

Development of disease.—Leaf spots showing the presence of the early blight fungus were abundant upon the unsprayed plots before the middle of August, and by the last of the month, taking the average of all varieties, about one-half of the foliage was killed. The extent of the injury varied, however, in direct proportion to the natural earliness of the maturity of the variety, as will be seen by a glance at the following records of conditions on August 28:

DAMAGE FROM EARLY BLIGHT ON UNSPRAYED PLANTS

Variety	Foliage killed	Variety	Foliage killed
Rural New Yorker No. 2	15 percent	Polaris	50 percent
Delaware	25 "	Early Rose	75 "
Green Mountain	50 "	Early Ohio	90 "

There was an abundant sprinkling of early blight spots on the remaining unsprayed foliage of all varieties at this date and all the tops on the unsprayed rows died during the next fortnight.

The crop on the sprayed plots showed a striking contrast to these. There was a slight amount of early blight present on the plants sprayed three times, though not enough to have caused practical injury. Careful search revealed scarcely a spotted leaf on those sprayed five times. During the following fortnight there was a slight increase in the amount of this spotting on the plants sprayed three times, though not enough to be of practical consequence; while those sprayed five times remained almost without a spot until the end of the season. This came on September 13, when all were cut down by an early frost.

The yields were as follows in pounds per row;

	Sprayed 5 times	Sprayed 3 times	Not sprayed
Rural N. Y. No. 2,[1]	60	74	55
Delaware,	59	52	23
Green Mountain,	54	49	22
Polaris,	40	42	27
Early Rose,	64	42	12
Early Ohio,	54	57	30
Totals,	331	316	169

[1]There was a large stump in these rows, which accounts for the relatively small gain shown where sprayed five times.

These figures are in complete accord with the verdict that had been reached from the appearance of the tops, viz.: that there was very decided gain from the spraying and that five applications is slightly better than three, but not enough so to be of much practical consequence.

Discussion of results.—Judging from the appearance of the plants, we attribute a considerable, perhaps nearly one-half, of the actual gain in yield to the beneficial effects of the bordeaux mixture in other ways than in checking the early blight fungus., i. e. in deterring insects from attacking the plants and in promoting their general vigor. Fully one-half was due to checking the early blight fungus. The foliage was practically free from the attacks of the late blight (*Phytophthora*) and there was no rot in any of these rows. It was therefore as complete a demonstration as could be desired of the efficacy of bordeaux mixture as a remedy for early blight, providing it is applied *thoroughly* and *in season*. We emphasize these points because, according to our observations, few potato growers realize sufficiently their importance.

II. RELATION OF DATE OF DIGGING TO DEVELOPMENT OF ROT

Investigation into this question in previous years[1] has led to interesting conclusions of much practical significance. The conditions of the summer of 1905 were somewhat different from those when the previous trials were made, so it was thought desirable again to make trial diggings at different dates.

Details of experiment.—The soil was a heavy undrained clay loam, ill adapted to potato culture at best, and especially so in a wet season like that of 1905. The variety was State of Maine, planted about the middle of May. No fungicides were applied. The late blight fungus appeared on the foliage about the 20th of August and spread slowly

[1]Vt. Sta. Rpt. 17, p. 391 (1904) and earlier literature there cited.

but persistently until the middle of September, when substantially all the tops were dead. Owing to the frequent September rains this soil was wet practically throughout the month. This fact must be borne in mind in considering the results. Part of the tubers were dug on each of two dates, September 9 and October 7. These were in each case wet, with considerable soil clinging to them when dug. They were allowed to lie in the field a few hours to dry off, then stored in shallow boxes, well ventilated, in a dry cellar at a temperature of 50-55° F. There was some loss of weight attributable to the dirt which rattled off these tubers at the later weighings, but this was essentially the same in all rows, and since the data give comparative rather than absolute values, this may be disregarded. The results as to total yields and subsequent rot are as follows:

DETAILS AS TO YIELDS AND DECAY WHEN DUG AT DIFFERENT DATES

Row No.	Date of Digging	Condition when dug				Condition Sept. 15				Condition Nov. 11			
		Sound		Rotten		Sound		Rotten		Sound		Rotten	
		No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight
I	Sept. 9	580	88 lbs.	0	0 lbs.	560	78 lbs.	20	3.6 lbs.	440	56 lbs.	120	17.6 lbs.
II	Oct. 7	288	44.3 lbs.	250	38.5 lbs.	....	....	....	....	244	34.8 lbs.	44	6.7 lbs.
III	Sept. 9	558	88 lbs.	0	0 lbs.	498	74.4 lbs.	60	8.6 lbs.	333	43.2 lbs.	165	2.4 lbs.
IV	Oct. 7	214	31.5 lbs.	270	39.8 lbs.	....	....	....	....	194	25.8 lbs.	20	3.9 lbs.

Adding together the results from rows I and III and from II and IV respectively, the following figures are obtained:

Dates of Digging	Total amount when dug		Condition when dug				Final condition				Percent of crop saved	
			Sound		Rotten		Sound		Rotten			
	No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight	By no.	By weight
Sept. 9	1138	176 lbs.	1138	176 lbs.	0	0 lbs.	773	99 lbs.	365	54 lbs.	68%	56 %
Oct. 7	1022	154 lbs.	502	76 lbs.	520	78 lbs.	438	61 lbs.	584	88 lbs.	43%	40 %

Discussion of results.—The results are capable of but one interpretation. There was greater loss from the later digging than from the earlier. This is an outcome radically different from those of the previous trials extending through the three years 1902-04 and involving the averages from six fields and five varieties in 1902, one field and one variety in 1903, and one field and six varieties in 1904. In the light of these former results that of 1905 may be held to be the exception which may prove the general rule. Fortunately, observations,

which will be discussed in detail later, were also made at digging time which explained the result. Suffice it to say here that it was found that owing to the excessive rain and the heavy soil the rot fungus (*Phytophthora*) was forming spores on the surface of many of the tubers during the latter part of September. This has never before been observed by us, and is probably an exceptional thing. Yet it is doubtless the fact that a considerable part of the rot which destroyed the later dug tubers in the present field was the result of inoculation from such spores in the soil between the dates of the earlier and later diggings. Reviewing the details of our former results in the light of this conclusion, we are led to believe that a similar condition of affairs has only once before occurred, viz., in the south plot of Holt's field, 1902.[1] The figures there show a loss from late digging about like the present and the soil conditions were similar, viz., a heavy wet clay loam. The rule[2] which was formulated as the result of previous experiments was favorable to late digging where the rot is feared. We would now modify it by making an exception of heavy wet soil in a wet season. Of course every potato grower avoids such soil as unsuited to the crop anyhow, providing he has other soils available, so this exception really affects but a minor portion of the crop. While this is our conclusion to date, it is planned to continue these trials upon various types of soils and under varying conditions as to disease until no doubt can be left in the matter.

III. RELATION OF STORAGE CONDITIONS TO DEVELOPMENT OF ROT IN POTATOES

Favorable opportunity was secured for making a number of experiments to determine the relation of storage conditions to the development of rot in potato tubers. For this purpose tubers were taken from the same field as in the preceding experiment. As explained, these were State of Maine potatoes and the soil was a heavy, moist, clay loam. The soil is poorly suited to potato growing in any season, and was especially so where there was much rain in late summer as in 1905. No fungicide was applied to the plants and the late blight developed considerably on the tops. The rains kept the soil so continually wet during September that much of it clung to the tubers at digging time. Every condition, therefore, favored a considerable development of rot in the storage cellar. With this expectation in mind, four questions were formulated, some having a more direct practical interest than others:

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[1]Vt. Sta. Rpt. 15, pp. 219-224 (1902).

[2]Vt. Sta. Rpt. 17, p. 395 (1905).

1. Does liming prevent rot?
2. Will disinfection with formalin lessen rot?
3. Will sun-drying the tubers lessen rot?
4. What is the relation of temperature of storage to rot?

DOES LIMING PREVENT ROT?

Results obtained during the last two years[1] have given negative replies to this question. Since the conditions of the field just described promised an excessive loss from rot, it was decided to repeat the trial once more. In order to test the lime more thoroughly it was decided to try it on both moist and dry tubers. Therefore two rows were selected. The digging was begun on the morning of a bright, clear day, and the tubers of the first row were dug early and allowed to dry thoroughly before taken to the cellar. Those of the second row were taken in while still moist, indeed almost wet, the ground being low and damp. No rotten potatoes were found in the first row at digging time, and only three in the second; but the occurrence of late blight on the tops, together with the soil conditions, made us confident that there would be a considerable rot in the tubers. When the tubers were placed in storage air-slaked lime was scattered over one-half of each lot, at the rate of a pound of lime to three bushels of potatoes. This sufficed to give the surface of each potato a liberal coating, and certainly is as much as anyone who has either to use or to attempt to sell the tubers would ever apply. All were stored in shallow boxes, well ventilated, in a dry cellar at a temperature of 50-55° F. They were sorted twice, first September 15, one week after storing, and again on November 11. The results follow:

Row No.	Condition when stored	Treatment when stored	Amount when stored		Sorted Sept. 15				Sorted Nov. 11			
					Sound		Rotten		Sound		Rotten	
			No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight
I a	Dry	Lime	159	22 lbs.	141	18.2 lbs.	18	2.1 lbs.	102	10.8 lbs.	39	6.3 lbs.
I b	Dry	None	145	22 lbs.	140	19.5 lbs.	5	0.9 lbs.	112	14.0 lbs.	28	4.8 lbs.
II a	Moist	Lime	109	22 lbs	92	17.0 lbs.	17	2.9 lbs.	55	8.8 lbs.	37	7.4 lbs.
II b	Moist	None	184	22 lbs	118	17.8 lbs.	16	2.5 lbs.	80	10.8 lbs.	38	5.4 lbs.

Bringing these figures to the percentage basis, it appears that the losses were as follows:

[1] Vt. Sta. Rpts. 16, p. 163 (1903), 17, p. 395 (1904).

Dry, limed.	35%	of number,	52%	of weight
Dry, no treatment,	23	"	36	"
Moist, limed,	50	"	61	"
Moist, no treatment,	40	"	54	"
Average, limed,	42.5	"	66.5	"
Average, no treatment,	31.5	"	45	"

It is evident, therefore, that instead of being an advantage in the preservation of the tubers, the lime appeared actually to favor the rot.

Discussion of results.—In the first place it would be well to compare these results with those of the preceding trials, taking the loss in weight as the basis of comparison.

In 1903,	loss where limed, 29%;	no treatment, 27%
In 1904,	loss where limed, 9%;	no treatment, 11%
In 1905,	loss where limed, 66%;	no treatment, 45%

In two years out of three, therefore, the loss from rot in the limed potatoes was actually greater than in the unlimed ones. It is hard to escape the conclusion, therefore, that instead of checking the rot, liming probably actually favors it. Certainly when one takes into consideration the further fact that the lime coating makes the tubers disagreeable to handle and hard to prepare for cooking, it becomes evident that liming potatoes is to be condemned as worse than useless. As noted last year, the evidence so far as obtained by others favors this same conclusion.[1]

WILL DISINFECTION OF TUBERS LESSEN ROT?

So far as is known to the writers this question has never been determined, unless the use of lime as described in the last experiment be considered a disinfecting process. Although it might not usually seem practicable to disinfect potatoes, even if there was some lessening of rot by some such process, yet one can conceive of conditions where such a procedure would be applicable, especially for growers of seed potatoes. Moreover, it is of considerable interest as contributing to the understanding of the time and mode of infection by the fungus.

Details of experiment.—The potatoes were left on the ground several hours after digging to sun-dry, and as they were gathered up they were carefully divided into two lots, one-half from each hill going into each lot. Lot I received no treatment; lot II was soaked for an hour in a solution of 8 ounces of Merck's formalin in 15 gallons of water, i. e. 0.4 percent solution, the same strength as used in disinfection against scab. These tubers were then spread upon the cellar

[1] Vt. Sta. Rpt. 17, p. 397 (1904).

bottom for twenty-four hours to dry. Both lots alike were stored in shallow wooden boxes, well ventilated, in a dry cellar held at a temperature of 50-55° F. The outcome was as follows:

Lot No.	Treatment before storing	Amounts stored		Sorted Sept. 15				Sorted Nov. 11			
				Sound		Rotten		Sound		Rotten	
		No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight
I	None	290	44 lbs.	280	39 lbs.	10	1.8 lbs.	220	28 lbs.	60	8.5 lbs.
II	Formalin	293	44 lbs.	272	38.1 lbs.	21	2.9 lbs.	231	29.5 lbs.	41	5.7 lbs.

From these figures it is evident that the formalin disinfection was without material effect in checking the rot. This result is the more noteworthy in view of the fact that these tubers had much of the clay soil clinging to them and that the untreated tubers were in a moist condition when stored.

Relation of moisture to rot.—Of course the presumption is that tubers will keep better if dried before storing and kept dry thereafter. Since the soil was very wet at time of digging in one field where rot was feared, it was considered worth while to put this matter to the test. Accordingly, two rows were dug on a very bright sunny autumn day, favorable to quick and thorough drying. One-half of each hill was picked up promptly after digging while still moist and constituted the lots called *a*. The other half of each hill was left in the sun several hours and turned once meanwhile, thus securing pretty thorough sunning and drying of the surface; these constituted the lots called *b*. All were stored alike in a dry cellar in shallow, well ventilated boxes at 50-55° F. Very little rot was found in these at digging time, September 9, but as was expected, much developed in storage. The tubers were sorted twice with the following results:

Row No.	Condition when stored	Amounts stored		Sorted Sept. 15				Sorted Nov. 11			
				Sound		Rotten		Sound		Rotten	
		No.	Weight	No.	Weight	No.	Weight	No.	Weight	No.	Weight
I a	Moist	279	44 lbs.	230	30.6 lbs.	49	8.5 lbs.	163	19.0 lbs.	67	7.9 lbs.
I b	Dry	306	44 lbs.	271	36.2 lbs.	35	4.1 lbs.	200	24.5 lbs.	70	9.4 lbs.
II a	Moist	335	55 lbs.	295	44.5 lbs.	40	6.8 lbs.	200	25.3 lbs.	105	13.8 lbs.
II b	Dry	349	55 lbs.	311	46.5 lbs.	38	5.4 lbs.	208	27.0 lbs.	103	15.0 lbs.

It is evident, therefore, that the results were more favorable where the tubers were stored dry, whether one considers number or weight

of sound tubers on November 11. Averaging the two lots and reducing to a percentage basis the gain is as follows: Based on numbers of tubers, 62 percent of the crop was saved where stored dry as contrasted with 59 percent where stored moist. Based on weight of tubers, 52 percent was saved where stored dry as contrasted with 45 percent where stored moist. It is further noteworthy that the gain occurred, as one might naturally expect, during the first few days following storage; indeed, in the last period there was slightly more loss among those which were dried before storing. One is led to ask why this is so. Three possible explanations occur to us. First, it may be due to infection during storage, as shown later in this report; second, it may be that the moister conditions stimulate or favor a more vigorous or destructive development of the fungus already in the tubers; third, it may be that the moister condition of the tubers keeps them in a condition permitting or favoring destructive invasion by the fungus. Whatever the explanation, the practical conclusion is the same, viz.: that potatoes should be allowed as much exposure to sun and air as practicable before storage, providing loss from rot is anticipated.

RELATION OF TEMPERATURE OF STORAGE TO DEVELOPMENT OF ROT

Everyone realizes the probable importance of this factor. Potatoes are, however, so little handled in cold storage in the regions where rot prevails that no exact records have been secured on this point so far as we know. The following experiments were planned with this end in view:

Some six bushels of tubers were dug September 22 from the field already described and divided into three like portions. Each was placed in a barrel. The first was stored near the greenhouse boiler at a temperature approximating 70° F.; the second in a cellar at 50-55° F.; the third in a cold storage house at 40° F. The tubers of lots I and II were sorted twice, but to simplify the presentation only the final conditions are presented as existing on November 18, when the last sorting was done:

Lot No.	Storage temperature	Amounts stored Sept. 22		Conditions Nov. 18				Percent of crop saved	
				Sound		Rotten			
		No.	Weight	No.	Weight	No.	Weight	By no.	By weight
I	70	850	116 lbs.	275	86 lbs.	575	65 lbs.	32%	31 %
II	58	691	116 lbs.	352	54 lbs.	339	51 lbs.	51%	47 %
III	40	756	116 lbs.	650	96 lbs.	106	17 lbs.	86%	83 %

Discussion of results.—This outcome is one of the most interesting of the entire series and of much practical significance. Potatoes have sold in the Burlington market this year for 80 to 90 cents a bushel. There would have been an immense saving and a wide margin of profit if more potatoes had been placed in cold storage. While it may not prove practicable for the smaller growers to do this, it certainly behooves everyone to appreciate the importance of placing the crop in the coldest storage room available and as promptly as possible after digging, when much rot is anticipated. It is proposed later to transfer to a warm room portions of these tubers which have been kept from rotting by cold storage. It is of practical as well as theoretical interest to learn whether in such case further rot will develop in midwinter.

IV. STUDIES AS TO THE TIME AND METHOD OF TUBER INFECTION BY THE ROT FUNGUS

This is a question of much practical importance and about which there is incomplete knowledge. It has generally been held by plant pathologists that it results from spores borne on the leaves and washed thence through the soil to the tubers. The results of our soil spraying experiments already described are in general agreement with this idea. Granting this, however, some practical questions remain unanswered.

Does the fungus spread from tuber to tuber in the soil?

Can such infection occur with fully mature tubers or only with the immature ones?

May tuber infection result from the contact of spore bearing tops with tubers at digging time?

First, as to the possibilities of spread from tuber to tuber in the soil. It has heretofore been stated that there was much rainfall in September and close watch was kept of the progress of the fungus upon the tubers growing in moist heavy clay loam. On the area under consideration the blight destroyed practically all of the foliage before the middle of September. Meanwhile the rot had begun to develop upon the tubers, very little being found September 9. It rapidly spread during the last half of the month. Upon digging at different times and places during this period the fungus (*Phytophthora*) was frequently found growing in tufts from the surface of such decaying tubers; and such tufts were always richly covered with spores. Moreover, soil conditions were favorable for their development and for further infection of tubers, as was shown by the fact that some of these spores were found in process of germination, i. e. zoospore

formation. Moreover the fungus threads or mycelium were found ramifying through the interstices of the soil for one-fourth to one-half of an inch from the surface of such decaying tubers and there sporulating abundantly. Doubtless this growth was made possible in the soil by the impregnation of the earth by the juices or infusions from the decaying potatoes which were close at hand.

These observations convinced us that the fungus was under these circumstances capable of spreading from tuber to tuber in the soil. Evidence that this actually occurred was presented earlier in this report, pages 274-275, in connection with the account of the trial as to digging at different dates. That experiment was made in this same field and showed a rapid increase in amount of rot where the tubers were left in the ground during the last half of September, although, as already stated, the foliage was practically all destroyed earlier. In the light of our experience, however, such rapid and destructive spread of the fungus from tuber to tuber in the soil is believed to occur but exceptionally, probably only in wet heavy lands. Further observation on this point is needed, since it is of much practical significance.

These observations led to the giving of more careful attention than heretofore to the possibilities of infection of the matured tubers either by contact with spore bearing foliage at digging time or by spread of the fungus from tuber to tuber during storage. The following results show that infection may occur in either way if conditions are sufficiently favorable.

In order to test the possibility of infection of tubers by spores from the foliage at digging time, the following experiment was carried out: On September 9 some State of Maine potatoes were dug, whose tops had blighted badly and were two-thirds dead. The tubers appeared fairly mature. Less than four percent of rot showed at digging time. Subsequent developments of the rot showed that more infection had occurred in the field than was suspected at the time, otherwise tubers from another source would have been chosen. The soil was wet and much clung to these tubers, making them quite dirty and moist. They were taken to the storage cellar before fully dry and there divided into three lots of 44 pounds each. One lot (III) was at once placed in the storage cellar without treatment to serve as a control. Each of the other two was poured into a laundry tub with bottom drainage and treated as follows: One lot (I) was covered with a layer of potato branches, the leaves of which showed a considerable development of the blight fungus. To insure the fuller distribution of the fungus spores over the tubers water was then sprinkled over this foliage freely until it trickled from the bottom of the tub. The

sprinkling was repeated at the end of twenty-four hours, and when this foliage covering was removed from the tubers at the end of thirty-six hours it was still fairly fresh and bearing a rich crop of spores. There would seem to be the best possible chance for tuber infection under the circumstances.

Meanwhile the other lot (II) had lain in a similar tub without artificial infection, but covered with coarse sacking and water sprinkled over it the same as over I. It was designed to serve with lot III as a control on lot I.

Upon removing lots I and II from the tubs at the end of the thirty-six hour period they were wet and muddy. Lot II and one-half of lot I (called Ia) was placed in shallow layers on the cellar floor to dry, and when so dried at the end of twenty-four hours, was stored alongside of III. The other half of the lot (called Ib) was handled in the same way except that the mud was first washed from the tubers by a stream of water from the garden hose pipe. To recapitulate, then, the treatment of the three lots was as follows:

I. All tubers exposed for thirty-six hours to infection from blighting tops immediately after digging; one-half (Ia) left unwashed, the other half (Ib) washed.

II. Not artificially infected but kept moist for thirty-six hours after digging as was I.

III. Stored without treatment immediately after digging.

All were kept in like storage in ventilated shallow boxes in a dry cellar at a temperature of 50-55° F. They were sorted twice, with the following results:

Lot No.	Treatment before storing	Original weight	Sorted Sept. 15		Sorted Nov. 11	
			Sound	Rotten	Sound	Rotten
I a	Infected, unwashed	22 lbs.	17.7 lbs.	4.1 lbs.	1.6 lbs.	13.0 lbs.
I b	Infected, washed	22 lbs.	14.8 lbs.	6.0 lbs.	0 lbs.	12.4 lbs.
II	Control, kept moist	44 lbs.	34.2 lbs.	6.0 lbs.	10.1 lbs.	19.0 lbs.
III	Control, untreated	44 lbs.	35.6 lbs.	5.0 lbs.	20.2 lbs.	11.0 lbs.

The relative loss was, therefore, about 92 percent where infected and not washed, 100 percent where infected and washed, 77 percent where not infected but kept moist for thirty-six hours, and 54 percent where stored at once without any treatment. There can be no doubt from these figures as to the possibility of tuber infection at digging time, provided conditions are sufficiently favorable, i. e., an abundance of spores and moist conditions. Probably the higher percentage of infection where the tubers were washed was simply due to bringing

the spores which were already on the tubers into closer contact with their surface, and especially of lodging them in the eyes along with adequate moisture for their germination. It is possible that a part of the excess of loss in lot II over lot III was due to infection following digging by spores clinging to the tubers. Most of it is, however, attributed to the stimulation to hastened growth of the fungus already present in these tubers.

Concerning the possibility of spread in the storage cellar, positive evidence has been obtained along two lines:

First.—Spores may be produced in storage. Reference has been made to the abundant sporulation of the fungus on decaying tubers in the soil. Equally rich crops of spores were found in stored potatoes during October. Moreover, these were on tubers in shallow boxes in a dry cellar at temperature of 50 to 55° F. Doubtless they would be produced more abundantly under moister and warmer conditions.

Second.—Well ripened sound tubers were taken during this same month (October) and successfully inoculated[1] with the fungus spores.

Such inoculations have been secured by applications of the spores to cut surfaces of the tubers, but almost as certainly by placing drops of spore-containing water in the eyes of mature tubers kept in a moist chamber. The results leave us in doubt as to the outcome from similar applications upon lenticels. Probably, however, infection does not occur through the lenticels or the unbroken epidermis of the mature tubers.

There can be no doubt, therefore, as to the possibility of infection of tubers in storage. Probably many tubers are so infected during the first fortnight after digging where there is much moisture and a high storage temperature, say above 60°F. It is not thought that there is enough danger to be of practical moment, however, providing the tubers are dry when placed in storage and kept continuously dry and cool during the first month thereafter.

V. GASEOUS DISINFECTION FOR POTATO SCAB

This is a direct continuation of the trials which have been made during several preceding years[1] aiming to secure a satisfactory method for the disinfection of seed potatoes by gaseous treatment in lieu of soaking. These preceding trials have encouraged belief in the efficacy of formaldehyde gas for this purpose. The aim in the present trials was, first, again to test the fundamental question of the relative value of gaseous treatment as compared with soaking the seed for dis-

[1]These inoculation experiments were performed by Mr. N. J. Giddings, a student in the botanical laboratory.

[1]Vt. Sta. Rpt. 17, p. 397 (1904) and previous reports there cited.

infection against scab; and, second, to make trial of the merits of different ways of generating the gas.

The experiment was carried out, as heretofore, on recently cleared pine land, virgin soil, which is a light sand and supposed to be free from the scab germs.

The Delaware variety has proved in our trials to be especially liable to scab, so it was selected for use. One-half the seed used was very scabby, every tuber having the surface sufficiently pitted by the disease to render it unmarketable. The other half was perfectly smooth seed, but sorted from a crop showing considerable disease, and so presumed to have the spores or germs of the disease on the surface. To make such infected condition the more certain, dust and scrapings from scabby tubers were sprinkled over the surface of this smooth seed before disinfection. The aim was to secure in this way a condition of seed infection at least as bad as would exist in any case where smooth tubers were sorted from a lot containing much scab.

These smooth and scabby seed tubers were then each divided into five lots, there being a little less than a peck of each lot. These lots were handled in pairs in the subsequent disinfecting and planting, i. e. a scabby and a smooth lot going together to constitute a pair, treated alike and planted as two parallel rows in one plot. The treatments before planting were as follows:

I. Soaked two hours in a solution of 8 ounces of Merck's formalin in 15 gallons of water. This is the standard method of disinfection and used as a basis for comparison.

II. The dry seed inclosed for 24 hours in a tight box of 8.2 cubic feet capacity, into which was conducted the gas (formaldehyde and water vapor) generated by the evaporation of 25 c. c. of Merck's formalin diluted with water. At the beginning 100 c. c. of water was added and this was constantly replenished, so that at the end of one hour one-half the volume of the liquid still remained. This was then boiled down to about 10 c. c. This method has been found to vaporize all the formalin.[1]

III. Dry seed enclosed for 24 hours in a tight box as in II, except that the gas was generated by the permanganate method.[2] This consisted in placing in the disinfecting box a shallow dish with flaring sides, containing 9.375 grams of potassium permanganate, and pouring on this 25 c. c. of Merck's formalin (i. e. in the proportion of three

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[1]For further details as to this method see Vt. Sta. Rpt. 17, p. 398 (1904).

[2]This method of generating the gas was first advocated and its usefulness for general disinfecting purposes shown by Evans and Russell, Maine State Bd. Health Rpt. 13 (1904). The details of the trials there given show that 81 percent of the total gas in solution is liberated by this method and so suddenly as to increase its effectiveness.

parts permanganate to eight parts formalin). The box was sealed immediately after the addition of the formalin and so left for 24 hours.

IV. The formaldehyde gas generated as in III, but instead of leaving the seed in a dry atmosphere, water vapor (steam) was conducted into the box for one hour, exactly as in lot II. The aim here was to secure conditions identical with II as to moisture conditions, but differing as to the method of volatilization of the formaldehyde gas.

V. Left untreated as a control.

A thermometer in the disinfection box showed the temperature to range from 60° to 70° F. during the experiment, except during the discharge of vapor into the box in experiments II and IV, when it ranged between 70° and 80° F.

The planting was done May 5, in plots following the order just given, each plot consisting of two rows 75 feet long, one planted with scabby, the other with smooth seed of like treatment, one-half peck of seed per row. Each plot was separated from the next by 25 feet of unplanted ground to lessen danger of cross infection. All germinated well and alike, there being no evidence of ill effect of the treatment upon the growth. The plants were dusted with paris green on July 15 and five applications of bordeaux-paris green mixture were made on subsequent dates at intervals of about a fortnight during July and August, as in the spraying experiment already described for prevention of early blight.

They were dug October 13 and subsequent sorting showed the following conditions as to yield and scabbiness. The variations in yield should be accorded no consideration, since all the plants were equally healthy. They resulted from the local soil variations, largely due to the interruption of the rows by the remains of pine roots and stumps.

Plot No.	Treatment of seed	Condition of seed	Total yield		Smooth tubers		Scabby tubers		Percent scabby	
			No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
				lbs.		lbs.		lbs.		lbs.
I.	Soaked in formalin sol.,	Smooth,	436	46.4	417	44.4	19	2.0	4	4
		Scabby,	324	24.0	281	20.4	43	3.6	13	15
II.	Formalin vaporized,	Smooth,	537	48.3	528	47.9	9	0.4	2	1
		Scabby,	578	49.2	561	47.8	17	1.4	3	3
III.	Permanganate method,	Smooth,	498	31.3	469	29.0	29	2.3	6	7
		Scabby,	450	38.0	441	36.5	9	1.5	2	4
IV.	Permanganate meth. & steam,	Smooth,	374	27.8	363	26.8	11	1.0	3	4
		Scabby,	354	31.7	343	30.4	11	1.3	3	4
V.	Control; no treatment,	Smooth,	310	33.2	225	22.7	85	10.5	27	32
		Scabby,	389	34.2	119	12.7	270	21.5	79	63

Discussion of results.—In all our potato scab experiments minor irregularities have occurred, due probably to variations in soil, drainage or humus content or, possibly, to cross infection in the field. The larger percent of scab from the smooth seed of plot III above is an example of this. With this exception the results are so uniform that there can be no doubt as to the conclusions. Scabby seed gives a far scabbier crop than smooth seed. All the methods of disinfection show marked gains, but none of them gives a crop wholly free from the scab. All of the vapor methods gave results which average ever better than did the soaking in formalin solution. Since these results are in accord with those of previous trials,[1] they are convincing as to the efficacy of formalin gas as a disinfectant against scab.

The other question is as to the best method of generating and applying the gas. The evidence seems on the face of it to favor slightly the direct vaporization of formalin by heat (plot II above). The difference between that and plot IV, where the permanganate method of gas generation was employed, is so little as to lead us to consider it within the limits of experimental error. In any case it is only a slight matter. In view of the relative convenience of the permanganate method it is to be recommended for practical use. The final question is as to whether this may be used alone as in plot III or whether in the presence of steam as in plot IV. The results this year apparently favor the use of steam. Again the difference is a small one and evidently within the limits of error, since in the case of the smooth seed, plot III, the evidence favors steam, while with the scabby seed it is against it. In the trials of former years, as detailed in the reports already referred to, the use of steam apparently reduced rather than increased the efficacy of the gaseous disinfectant. In view of this fact, therefore, the writers are led to recommend for practical use the generation of gas by the permanganate method and without the addition of steam.

The experiment was carried out on too small a scale to justify final conclusions as to the penetrating power of this gas into a bin of stored potatoes. It also leaves open the question of the minimum amount of formalin needed per cubic foot.

Careful observations have been made on both of these points by bacteriologists in connection with the use of this gas for disinfecting houses suspected of harboring germs of human diseases. They have found this formaldehyde method effective and the gas to have power of penetrating and disinfecting blankets, etc. In general the recommendations are to use 10 ounces of formalin per 1,000 cubic feet with

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[1]Vt. Sta. Rpt. 17, p. 401 (1904) and references there given.

closure of the room for 24 hours. Dr. B. H. Stone of the Vermont State Laboratory tells us that he prefers twice this amount for insuring the highest efficacy. In the experiments of Evans and Russell, already referred to, one quart per 1,000 cubic feet was used and found sufficient for perfect disinfection in three hours. In our trials 25 c. c. for 8.2 cubic feet were used, or the equivalent of about three quarts per 1,000 cubic feet. Since this amount did no harm there can be no objection to the use of so much except on the ground of added cost. From the evidence at hand we should advise for practical purposes that this be reduced by one-half, i. e. three pints per 1,000 cubic feet. This would still be from three to five times the amount required for bacterial disinfection. We believe that if this amount is used and the storage cellar be closed very tightly so as to hold the gas for forty-eight hours after its generation, it would penetrate ordinary potato bins, i. e. to a depth of several feet. It would be preferable, however, if practicable, to have the potatoes lying in shallow layers of say not over one foot depth.

To generate the gas on a large scale an earthenware basin (wash-bowl) or jar is the best dish to use. It should have a capacity of about a gallon for each pint of formalin; e. g. a three gallon dish if three pints of formalin are to be used. The formula requires that three parts of potassium permanganate be mixed with eight parts of formalin. Thus three pints (pounds) of formalin require 18 ounces of permanganate. This should be placed in the bottom of the jar, then the formalin poured over it, the operator at once retiring from the room and closing it as tightly as possible. The cost of the chemicals as quoted by retail druggists would approximate $1.50 per 1,000 cubic feet. As stated in former reports, the ordinary potato grower will do better to disinfect his seed by soaking in the formalin solution. This method of gaseous disinfection is recommended only for those seed potato specialists who may wish to disinfect hundreds or thousands of bushels of tubers.

FURTHER STUDIES IN LETTUCE CULTURE

WM. STUART

Lettuce culture was discussed under three heads in the last annual report:[1]

(1) The comparative value of different forms of chemical fertilizers;

(2) The relative value of chemical fertilizers and rotted manure;

(3) The relative influence of surface and sub-watering.

The subjects discussed in the present article are:

(1) Flat grown versus bench grown plants;

(2) Combination indoor and outdoor lettuce culture.

I. FLAT GROWN VERSUS BENCH GROWN PLANTS

The usual practice of market gardeners in this vicinity is to grow lettuce rather close together in the greenhouse bench, say from four to six inches apart, and when about two-thirds grown to transplant to flats or boxes averaging 12x15 to 14x20 inches in surface area, and containing from one to two dozen plants. This rather unusual practice is the result of a preference on the part of the dealers thus to handle open head or curly lettuce. The grower receives forty cents per dozen for plants thus raised.

The object of the present trial was to determine whether it was feasible to grow the plants in flats, from the time of transplanting to the bench till ready for market, and, if so, whether relatively as good returns could be secured. The flats used were especially constructed for the purpose, having interior dimensions of 12x16x3½ inches, and were designed to hold one dozen plants. The bench grown plants were set at a distance of 8x8 inches or four times the surface area of those in flats. This space was allowed because previous trials had shown that Grand Rapids lettuce would easily occupy, and indeed required, all this area for its full development. In order to furnish an abundance of plant food to the flat grown plants, the bottom of the flat was filled to a depth of 1½ inches with well rotted manure. The soil in the bench was also liberally supplied with rotted manure. Two sections in the lettuce room, each containing a superficial area of about 68 square feet, were equally divided, one-half of each being occupied by the flat grown plants, the other by those grown in the bed.

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[1]Vt. Sta. Rpt. 17, pp. 431-439 (1904).

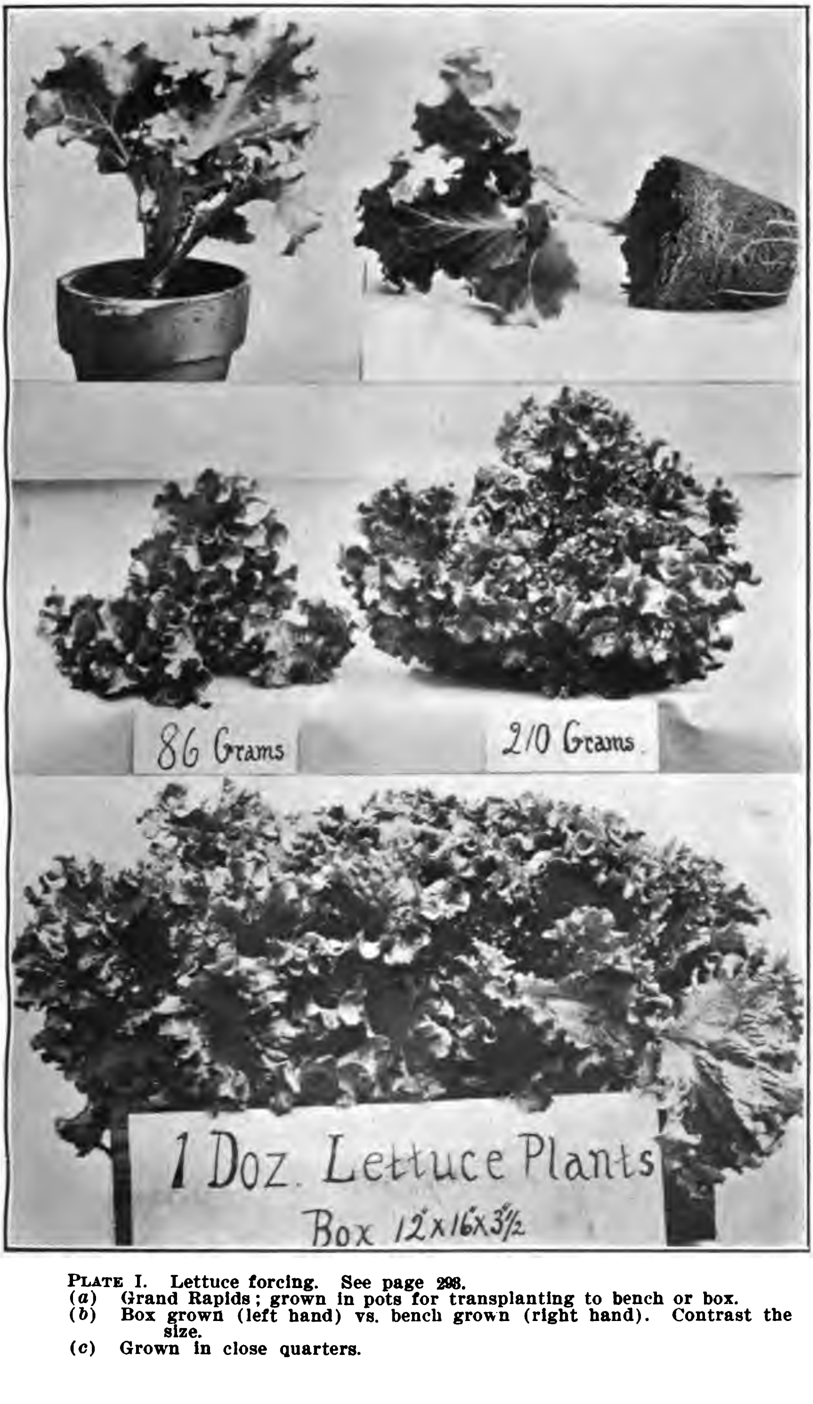

PLATE I. Lettuce forcing. See page 298.
(*a*) Grand Rapids; grown in pots for transplanting to bench or box.
(*b*) Box grown (left hand) vs. bench grown (right hand). Contrast the size.
(*c*) Grown in close quarters.

a b c d

PLATE II. Rhode Island Greening apple tree. Winter injury and severe pruning.
(*a*) Before pruning, June 9, 1904; showing extent of damage.
(*b*) After pruning, June 9, 1904. (*c*) August 15, 1904. (*d*) September 27, 1905.
(See page). Compare with opposite plate.

a b c

PLATE III. Rhode Island Greening apple tree. Winter injury; tree left unpruned.
(*a*) June 9, 1904. (*b*) August 15, 1904. (*c*) September 27, 1905.
(See page 300). Compare with opposite plate.

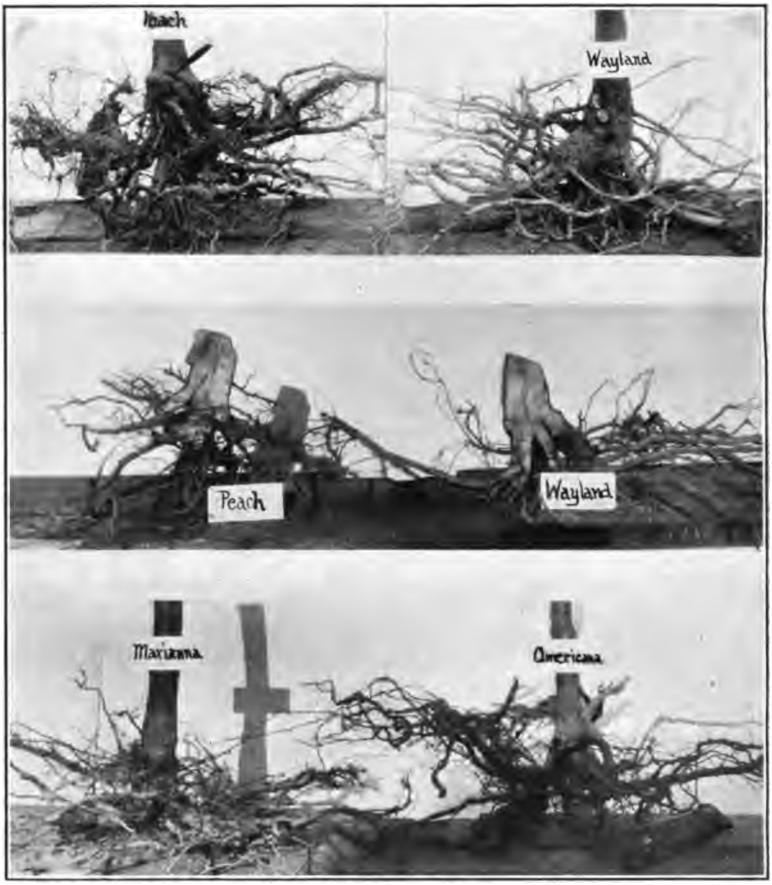

PLATE IV. Root system of Newman plum on Peach, Wayland, Marianna and Americana stocks.

(*a*) Newman on Peach and Wayland stocks. The root at point where knife is inserted came from the scion. (See page 304).

(*b*) Vertical section of the two stumps shown at (*a*) through point of union between scion and stock.

(*c*) Newman on Marianna and Americana; compare root systems with those of Peach and Wayland.

Cultural notes.—The seed was sown November 11, potted off into 2½ inch pots November 23, and transplanted to the bed and flats January 4, the plants at this time being about the size of those shown in figure 1. The flats were imbedded in the soil so as to make the general level of the plants the same as those in the bed.

Results.—The plants in the flats, owing to their crowded condition, were ready for market possibly a week in advance of those in the bench; but, as will be noted, they were very inferior in size. The relative size of the lettuce grown in flats and the bench is well illustrated in figure 2, which represents average plants of 86 and 210 grams (about three and seven ounces respectively). Notwithstanding the smallness of the flat grown plants, they nevertheless presented a good appearance in the flat (see figure 3), and sold readily at forty cents, while those grown in the bench commanded but fifty cents per dozen.

Profit.—It is obvious that while the product of the flats was much inferior to that of the bench, the profit from them was much greater from a given area. The box flat containing a dozen plants occupying a surface area of about 13x17 inches, while the dozen bench grown plants occupied 24x32 inches; or, relatively speaking, about as 1 to 3.5. Expressed in terms of dollars and cents per area occupied, the returns per square foot were twenty-six cents from the flat grown plants as against less than ten cents from the bench grown ones. These results show under existing conditions of marketing a very decided advantage in favor of closer planting in the bench. Where the quality rather than the number of plants is the goal, these differences would not be so great; in fact, the bench grown plants ought to and might prove the more profitable with a fancy trade. Likewise in markets where the crop is sold by weight the larger and heavier lettuce would very nearly equal the lighter but more closely grown plants.

Conclusions.—The investigations above outlined seem to warrant the following deductions:

1. Under the local market conditions a greater net profit may be secured from closely planted lettuce than from that given sufficient space to develop into full sized plants.

2. The growing of plants in flats to maturity, or, at least, to saleable size, is a feasible proposition and lessens the labor of lifting the plants and resetting in flats previous to placing them on the market.

3. It is not possible to grow as heavy or as good lettuce by close planting as by allowing sufficient space for best development of the plant.

II. COMBINATION INDOOR AND OUTDOOR LETTUCE CULTURE

The local consumption of head lettuce is considerable during the winter and spring season, in fact, during all but the height of the summer season; yet the market gardeners of this section do not attempt to grow it, the supply being all obtained from Boston commission houses. This is largely due to lack of suitable soil, and to some extent, no doubt, to failure on their part properly to appreciate the cultural requirements of the lettuce crop, which, if not complied with, is apt to induce functional derangement of the plant, as usually evidenced by tip-burn.[1] An invasion of fungi and bacteria usually follows the collapse of the cell tissues by tip-burn, which soon destroys the plant. Owing to these conditions the head lettuce crop has never proved a financial success with such local growers as have attempted it, although it always commands about double the price of curly leaved open head lettuce.

The unusually fine development in 1903 of head lettuce which had been started in the station greenhouse and transplanted to the open ground as soon as favorable weather obtained, suggested to the writer a method of lettuce culture, whereby plants, started early, either in the greenhouse, hotbed or coldframe, could be transplanted to open ground as soon as weather permitted, with every prospect of producing a fine quality of head lettuce, which, though somewhat late in the season, would still sell readily at fair prices. While the plan is not a new one, it seems not to have been practiced in this vicinity with head lettuce.

Varieties grown in 1904.—The following varieties of lettuce were grown in this way: Deacon, Big Boston, May King, Black Seeded Tennisball, Market Gardener's Private Stock, Iceberg and Improved Hanson; the last two being curly leaved varieties, but under proper cultural conditions forming good heads. The plants were started in the greenhouse, transplanted into flats and hardened off in the coldframes. They were set in the open ground in rows 15 inches apart and about 10 inches apart in the row.

Average weight of plants.—When the majority of the plants had arrived at their best development, all were cut and weighed. The average weight of ten plants of each variety was found to be as follows:

	Av. weight in grams	Av. weight in ounces
Deacon,	550	19.4
Big Boston,	377	13.3
May King,	312	11.0
Black Seeded Tennisball,	432	15.2
Market Gardener's Private Stock,	532	18.8
Iceberg,	778	27.4
Improved Hanson,	601	21.2

[1]In this connection see Vt. Sta. Rpt., 6, p. 85 (1893).

The varieties giving the best satisfaction were the Iceberg, Deacon, Market Gardener's Private Stock and Improved Hanson, in about the order named. While the average weight of the Improved Hanson exceeded that of all but Iceberg, it lacked the solid, well-blanched head of the Deacon and Market Gardener's Private Stock. May King made a close hard head of good quality, but lacked size. Big Boston made uneven heads. Some were more or less open, which made it seem unsatisfactory. Black Seeded Tennisball was fairly good, but not of sufficient merit to be classed with the best four.

Varieties grown in 1905.—Some of the varieties grown in the previous season were included in the 1905 experiments. The plants were grown in a similar manner to those of the year previous. In most cases, however, a larger number of plants were grown, thus affording more ample data upon which to base averages and general conclusions. The average weight of each variety was found to be:

	Grams	Ounces
Deacon, 26 plants,	562	19.8
Big Boston, 9 plants,	633	22.3
New York Cabbage, 39 plants,	853	30.0
Iceberg, 75 plants,	944	33.3
Improved Hanson, 15 plants,	894	31.5
Grand Rapids, 24 plants,	745	26.3

The results show in most cases a marked increase in size of plants over those of the preceding season. This may be accounted for by a more favorable growing season. Given in order of merit, they are as follows: Iceberg, New York Cabbage, Improved Hanson, Grand Rapids and Big Boston. Improved Hanson was much superior to the previous season, heading up more firmly and producing a large amount of well blanched lettuce. Iceberg again produced the heaviest heads of any on trial. The largest individual head of lettuce of each variety weighed as follows:

	Grams	Ounces
Iceberg,	1325	47
Improved Hanson,	1207	43
New York Cabbage,	1160	41
Grand Rapids,	995	35
Big Boston,	825	29
Deacon,	790	28

This crop sold readily at seventy-five cents per dozen, and in quality and size greatly exceeded that of any shipped head lettuce. The plants were grown in a fairly rich garden soil and received as fertilizer only a moderate application of manure previous to plowing the land. The soil was a rather fine, gravelly loam, well drained and fairly retentive of moisture. The labor involved in growing the plants up to the time of transplanting to the field was slight.

Cultural notes.—A hotbed with moderate bottom heat would serve to start the plants equally as well as a greenhouse. Seedlings from seed sown about the middle of March would be ready to transplant about the first week in April, and, if properly hardened off, could be set in the open ground the latter part of April or first of May. Good plants set in the open at this time should be ready for market in from five to six weeks.

Varieties.—The Iceberg lettuce is one of the best varieties of those tested for this kind of lettuce culture, as practically every plant makes a good, saleable head. New York Cabbage and Market Gardeners' Private Stock are two of the best of the plain leaf lettuce. Improved Hanson, next to Iceberg, is one of the best of the curly leaved types of heading lettuce.

Profit.—While the question of profit is always dependent upon demand and supply in the general market, local conditions sometimes make it possible to command much better prices than could be obtained in the large markets. Assuming that it were possible by successional plantings to dispose of the product of an acre of ground planted to lettuce in the manner described, what are the possible returns from said area? An acre of ground set with plants 12x15 inches apart would contain 34,848 plants or 2,904 dozen, which if marketed at seventy-five cents a dozen would give a return of $2,178. These returns could not, of course, be realized, as there would necessarily be a considerable percentage of plants that would fail to form saleable heads, while a considerable loss might result from plants throwing up flower stalks. Granting a 25 or even a 50 percent depreciation in plants or price, there still remains over a thousand dollars from the product of a single acre; certainly a very handsome return for the small outlay of capital required to engage in the work.

Conclusions.—The trials have shown:

1. That it is both feasible and profitable to grow good head lettuce in this vicinity by a combination of indoor and outdoor lettuce culture.

2. That the Iceberg and Improved Hanson of the curly leaved types and the New York Cabbage and Market Gardener's Private Stock of the plain leaved types gave the best general satisfaction of the varieties tested for this system of lettuce culture.

SOIL STERILIZATION

WM. STUART

Soil sterilization ranks as one of the most important of the more recent developments of greenhouse technique. On account of the severe injury so frequently caused by nematodes to tomatoes and cucumbers when grown under glass, the sterilization of greenhouse soil has almost become a necessity when the soil is thus infested.

DEVELOPMENT OF SOIL STERILIZATION

Disinfection of the soil by means of high temperatures was recommended by Sturgis[1] in 1892 as a remedy for nematodes infesting aster roots, the soil being heated on a sheet of iron over a fire. W. N. Rudd[2] described the following year a process of sterilizing soil in a specially constructed box, the bottom of which was fitted with steam pipes into which holes had been drilled to allow of the escape of the steam. The soil was placed upon these pipes to the depth of the box, over which a close fitting cover was dropped. Steam under high pressure was then turned on for a sufficient length of time to cook potatoes in any portion of the soil. According to Rudd the soil was sterilized to destroy grubs, larvae of insects and spores of fungi. Selby[3] gave in 1896 an account of some work in soil sterilization by a Mr. Lodder of Hamilton County, Ohio, who employed steam to destroy nematodes in soil to be used in growing cucumbers. The method employed was similar to that of Rudd's. Galloway[4] in 1897 described a method of box sterilization in which ordinary two-inch drain tiles are employed as conduits for the steam through the soil. Stone and Smith[5] enlarged upon Galloway's plan by using tile in the bottom of the greenhouse benches, their studies upon soil sterilization being the most exhaustive yet made of this matter. May[6] describes a method of sterilizing soil for roses, using boxes or bins, very similar in detail to the schemes proposed by Rudd and Lodder. This is at the present time one of the commonest methods of soil sterilization. A few large growers have constructed sterilizing apparatus by which they can sterilize soil in solid beds without the trouble of transferring it to a box for that purpose.

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[1] Conn. Sta. Rpt., 16, p. 148 (1892).
[2] Am. Florist, Vol. IX, p. 171 (1893).
[3] Ohio Sta. Bul. 73, pp. 231-232 (1896).
[4] Am. Gardening, Vol. XVIII, p. 127 (1897).
[5] Mass. Sta. Bul. 55, pp. 48-60 (1898).
[6] Am. Florist, Vol. XIII, p. 721 (1898).

STATION INVESTIGATIONS

The serious nematode injury suffered by a crop of tomatoes grown in the station greenhouse in the winter of 1902-03 showed that the winter forcing of tomatoes and cucumbers could not be successfully accomplished there unless the soil was sterilized. Since the larger portion of the space devoted to these crops was occupied by solid beds, it was thought desirable to attempt sterilizing this soil in place. Three-inch[1] drain tiles were sunk about ten inches below the surface of the soil. The lines of tile were laid every sixteen inches, each line being independent of every other, and connected with the surface by a vertical section of drain tile. The ends of each line of tile were plugged with paper and soil. The upright was connected with the laterals by a hole drilled through the upper surface of the end tile over which it was securely cemented. The verticals were connected alternately at one end or the other of the laterals, thus permitting the live steam to be injected at opposite sides of the bed, and thus equalizing the diffusion of heat throughout the soil. Not only were the tile joints open, but each section of tile was perforated with a quarter to a half-inch hole through each side, the better to facilitate the escape of the steam. Under a pressure of from 40 to 60 pounds of steam, a section of bed containing a surface area of nearly seventy square feet could be heated up to about 210° F. in approximately three hours' time. The surface of the soil being well covered with burlap, this temperature was maintained for a considerable period. In one case noted the thermometer stood at about 130° F. twenty-four hours after treatment. This procedure proved in every case an effective remedy against nematodes and obviated the labor involved in treating the soil in a box or other specially constructed device. The tile once placed lie so deep that they need not be molested in digging over the beds or in changing the soil, and are always ready for use in subsequent treatments of new soil. Then, too, the surface connection by means of vertical sections afforded ideal soil aeration.

STERILIZING SOIL IN SUB-WATERED BENCHES

Since nearly two hundred square feet of bench surface in one of the greenhouse rooms was fitted up for sub-watering by means of galvanized iron pans and layers of porous bricks, the question arose as to whether it was feasible to sterilize the soil in these benches by injecting steam into the pan through the watering tube. A thorough trial of this scheme showed that while it was possible thus to sterilize soil it could hardly be called a practical method, as it took too much steam to do it. It was found that the injection of steam into a pan full

[1] Two-inch tile might have served, but were not at hand.

of cold porous bricks resulted in a very considerable condensation of water, in fact, almost to the point of complete saturation of bricks and soil. In view of this experience it would seem to be more economical to employ a sterilization box for the treatment of soil in sub-watered benches.

Conclusions.—These trials indicate:

1. That sterilization of soil in a solid bed, using drain tiles as steam conduits, is both practical and feasible, and involves less labor while employing possibly a greater volume of steam.

2. That sterilization of soil in place in a sub-watered bed is not a desirable practice.

ON THE WINTER INJURY OF APPLE TREES

WM. STUART

Mention of an injury to apple trees during the winter of 1903-04 was made in the last annual report.[1] After the trees had blossomed and partially leaved out, growth was arrested and the partly unfolded leaves shrivelled and died. A little later in the season many of these trees pushed out new growths at the base of the scaffold limbs or somewhat higher up. This unusual occurrence was generally ascribed to winter injury of the roots; but continued observation of trees thus affected leads the writer to believe that some of the injury may have been due to severe freezing of the tops.

Pruning experiments undertaken with a view of bettering the condition of these trees were inaugurated in early June. In an orchard where a number of eight-year-old Rhode Island Greenings were severely injured, some of the trees were severely pruned back after the secondary buds had pushed out new growths, others were somewhat less vigorously handled, while yet others were left untouched. It was thought that the severe pruning of trees on which new growths were being pushed out at the base of the limbs would tend to throw all the strength of the tree into a few branches, thereby securing during the first season a much more vigorous development as well as a much more shapely head.

Cultural treatment of orchard land.—Unfortunately the cultural treatment of the orchard, which was not under the writer's control, was not such as to secure a healthy development of the trees. A crop of oats was grown in 1904 and the land seeded down to grass; a hay crop was removed in 1905. It is not to be wondered at that winter injury occurred with such treatment of a young orchard; indeed,

[1]Vt. Sta. Rpt. 17, pp. 418-19 (1904).

there is every evidence that the trees were in an unhealthy condition previous to the severe winters of 1902-03 and 1903-04. Hence the trees have not made the growth they should have made had they received good culture.

Results.—Photographs were made of the injured trees both before and after pruning June 9, again on August 15 of the same season, and a final set were made on September 27 of the present season. A careful study of this series of photographs affords little evidence that pruning was beneficial. A comparison of one set would show a decided advantage in favor of pruning, while that of another set was equally favorable to the unpruned. (See Plates II and III).

Conclusions.—While no very sweeping conclusions can be formed from a single experiment, conducted on a rather small scale and under unfavorable conditions, this much may at least be said:

(1) That in cases of winter injury like that mentioned above there is practically nothing to be gained by the hasty removal of the greater portion of the head of the tree; that, in other words, severe pruning is inadvisable and is probably more often injurious than beneficial.

(2) That in the light of the observations made it would seem advisable to defer pruning operations to the latter part of the growing season or possibly until the following spring.

(3) That whenever pruning is to be done no more branches should be removed than is necessary to preserve the balance of the tree top.

(4) That winter injury could be avoided by keeping the tree in a thrifty, vigorous condition. Weak, unhealthy trees are less able to stand extremes of temperature than thrifty ones.

INFLUENCE OF STOCK ON SCION

WM. STUART

The reciprocal influence of stock on scion has long been a subject of speculation and controversy, and at the present time is by no means a settled issue. The particular stock best adapted to each and every variety will probably never be exactly determined; but much work has been and will be done along these lines which in the end will furnish approximate knowledge of the stock best adapted to each class or type of fruit in different sections of the world.

With the idea in mind of elucidating some of these problems, the former horticulturist of this Station, Professor Waugh, undertook in

1899 studies in plum propagation with special reference to the influence of the stock on the scion, as evidenced more particularly in the union, form, and the growth and habit of the tree The results of his observations appear in previous publications of this Station.[1] Since the advent of the writer in 1902, no further report has been made upon the permanent trees which were set in 1900.

SUMMARY OF EXPERIMENT AND PREVIOUS REPORTS

Five distinct classes of plums were root grafted in 1899 on four as distinct types of stocks. The scions and stocks used were as follows:

Stocks	Scions
Americana	Stoddard of the Americana group.
Wayland	Green Gage of the Domestica group.
Marianna	Chabot of the Japanese group.
Peach	Milton of the Wild Goose group.
	Newman of the Chicasaw group.

The results of the experiment as deduced by observation and careful measurement during two seasons' growth led to the following conclusions:[2] "Stoddard made the strongest growth and did best in every particular on Americana roots. It was second best on Wayland roots and decidedly unsatisfactory on Peach. Green Gage [did best] on Wayland, with Americana second best. Chabot . . . did best on Marianna and Wayland, whereas it was decidedly poor on Peach. Milton [did well] on all stocks but Peach, [on which all] died. Wayland and Marianna [were] about equal. Newman . . . . did best on Wayland [with Americana second best.] Peach . . . gave poorest results."

In the next report[3] the following deductions were made: "Any one looking over the orchard at the close of the second year, fall of 1901, would find that Stoddard (Americana) has done best on Americana stocks. He will probably say that Green Gage (Domestica) has done best on Wayland, though the superiority is not marked. Chabot has done almost equally as well on Wayland, Americana and Marianna, though there is, perhaps, a slight preference in the order given. Milton has done uncommonly well on Marianna, Wayland and Americana in the order named. Newman is just about as good on one stock as another except on Peach, which seems to suit no type of plum in this soil."

"The best average growth has been made on Marianna,—Wayland and Americana standing nearly even for second place."

[1] Vt. Sta. Rpts. 13, pp. 333-354 (1900) ; 14, pp. 257-269 (1901) ; 15, pp. 249-260 (1902).

[2] Waugh, Vt. Sta. Rpt., 13, pp. 353-4 (1900).

[3] Waugh, Vt. Sta. Rpt., 14, pp. 268-9 (1901).

A further report was made in 1902 upon the growth of the previous season's grafts, but as it deals entirely with results obtained from trees grown in Maryland the deductions are hardly pertinent to Vermont conditions and may, therefore, be ignored in the present discussion.

The permanent trees were planted in the spring of 1900 These were selected from the best grafts of the previous season's growth and were set with a view of making more prolonged observations upon the rate of growth and habit of the trees. The number of living trees at the close of this season [1905] is as follows, there having been originally three of each set:

Stoddard on	Americana	All
	Wayland	All
	Marianna	Two
	Peach	None
Green Gage on	Americana	All
	Wayland	All
	Marianna	All
	Peach	Two
Chabot on	Americana	All
	Wayland	All
	Marianna	Two
	Peach	None
Milton on	Americana	Two
	Wayland	All
	Marianna	Two
	Peach	None
Newman on	Americana	All
	Wayland	All
	Marianna	All
	Peach	All

Total living on	Americana	14 of 15—	93 percent
	Wayland	15 of 15—	100 percent
	Marianna	12 of 15—	80 percent
	Peach	6 of 15—	40 percent

AVERAGE DIAMETER OF THE TREES

The trunk diameter of each tree just above the collar and one foot above ground, taken on Oct. 15, 1905, gives the following dimensions:

AVERAGE DIAMETER OF TREES ON DIFFERENT STOCKS OCT. 14, 1905

Variety of plum	Americana		Wayland		Marianna		Peach	
	Av. diameter at collar	One foot from ground	Av. diameter at collar	One foot above	Av. diameter at collar	One foot above	Av. diameter at collar	One foot above
	inches	inches	inches	inches	inches	inches	inches	inches
Stoddard,	2.00	1.75	1.69	1.32	1.69	1.44	....	....
Green Gage,	2.38	2.19	2.72	2.56	2.69	2.50	2.50	2.31
Chabot,	2.50	2.31	3.19	2.00	2.72	2.53	....	....
Milton,	2.41	2.00	2.50	2.22	3.28	3.19	1.03	.88
Newman,	3.03	2.69	3.16	2.97	3.03	2.97	2.88	2.75
Total,	12.32	10.94	13.26	12.07	13.41	12.63	6.41	5.94
Average,	2.46	2.19	2.65	2.41	2.68	2.53	2.14	1.98

These measurements show that Stoddard on Americana give the greatest average diameter of the trunk, with Marianna and Wayland about

equal. Green Gage did best on Wayland, with Marianna a close second, Peach and Americana being third and fourth respectively. Chabot was best on Wayland and second best on Marianna. Milton was far superior on Marianna than on any other, Wayland and Americana occupying second and third places. Newman did well on all stocks but was slightly superior, in diameter at least, on Wayland, followed by Marianna, Americana and Peach in the order named.

Expressed in percentages, assuming the growth on the individual stock which gave the best results to be 100 percent, the following figures are obtained:

		At collar	One foot above
Stoddard on	Americana	100	100
"	Marianna	84.4	82.2
"	Wayland	84.4	75.
Green Gage on	Wayland	100	100
"	Marianna	98.8	97.6
"	Peach	91.9	90.2
"	Americana	87.4	80.5
Chabot on	Wayland	100	100
"	Marianna	85.3	84.4
"	Americana	78.4	77.1
Milton on	Marianna	100	100
"	Wayland	76.2	69.6
"	Americana	73.3	62.7
"	Peach	31.4	27.5
Newman on	Wayland	100	100
"	Marianna	96	100
"	Americana	96	90.5
"	Peach	91.1	92.6

A careful study of the data shows that while Wayland gave better results with three of the five varieties used, its superiority over Marianna was so slight in all but one, that if the average growths of all the trees upon Wayland and Marianna stocks are taken, the latter exceeds Wayland by about four and one-half percent. Diameter measurements, therefore, indicate that there is little choice between these two stocks. If, however, the percentage of living trees can be considered as an indication of greater affinity between stock and scion the advantage is distinctly in favor of the Wayland stock. Stated briefly, Americana seems best for Americana; Wayland for the Japanese; Milton for Marianna, with little choice between Wayland and Marianna for the Domestica group; and no marked choice between any of the four stocks for the Chicasaw group.

INFLUENCE OF STOCK IN CHANGING HABIT OF GROWTH

A striking influence of stock on scion occurs in the Milton block of plums. This peculiarity has been noted by Waugh,[1] from whose report the following two paragraphs are quoted:

[1]Vt. Sta. Rpt., 14, p. 268 (1900).

"Returning to Milton, we have one interesting observation to make. The trees of this variety growing on Wayland roots are upright, narrowly vase-form with relatively few large branches. They are almost as narrow-headed as typical trees of Abundance or Chabot. On Marianna roots, in the very next row, the trees of Milton are low, round-headed, bushy, with thick spreading-drooping tops, much like trees of Marianna. If anything they exaggerate the typical character of the Marianna head. Moreover, the leaves are several shades darker and glossier and the twigs are dark red instead of being green as in trees of the same variety growing on Wayland roots. On Americana Milton has almost the same character as on Wayland. This is one of the most striking instances of the influence of stock on scion which the writer has ever observed."

At the present time the difference in color of foliage and bark of young twigs are not noticeable, neither is the "upright narrowly vase-form" head of Milton on Wayland anywhere near so pronounced. Notwithstanding these modifications, however, there is still a marked difference in the habit of growth of the trees upon Wayland and Marianna stocks. On Wayland the habit of growth is more or less upright, whereas on Marianna the head is low, bushy and spreading. Doubtless as the trees grow older these differences will tend to become less marked.

NEWMAN ON PEACH STOCK

The seemingly greater affinity exhibited by the Newman for peach stock than that of the other groups grafted upon it naturally raised the question whether the Newman scions might not have sent out roots of their own, in other words, whether they might not be virtually on their own roots. To satisfy these suspicions one tree of Newman upon each of the four stocks was dug up and the root systems carefully examined. On peach stock so far as could be definitely determined only one root proceeded from the scion, the balancè of the root system, which was quite extensive and rather deep, being from the peach stock. On the Marianna, Wayland and Americana stocks no roots from the scion were apparent. The exception in the case of the peach is not considered of any vital importance as it could not possibly have influenced the growth of the scion to any appreciable extent. A comparison of the root systems showed the peach to be the deepest rooted and least-spreading. Marianna and Wayland possessed numerous spreading and rather shallow lateral roots. Americana, while having a spreading lateral root system, was not as symmetrically developed as were the two former. In none of them could the root system be said to be much superior to that of peach stock. (See Plate IV).

SUSCEPTIBILITY TO "PLUM POCKET" OR "LEAF CURL" (*Exoascus pruni*)

When pruning trees growing upon different stocks in 1903, it was apparent to the casual observer that the Milton trees on Marianna stock were much more seriously affected with "Plum Pocket" than were those of the same variety on Wayland or Americana. The same observation was also made in the spring of 1904. Whether the greater prevalence of plum pocket upon these particular trees was accidental rather than due to greater susceptibility is, of course, rather a difficult question to answer, but from the fact that greater infection was noted both seasons, it would seem to indicate some predisposition to the disease. This predisposition may be an inherent one, or, as seems more probable, the tree may be rendered more susceptible through external causes. For example, the habit of growth of the tree—low, spreading and bushy—would naturally furnish more favorable conditions for the lodgment and germination of the fungus spores than would the more upright, open-headed tree. Granting this assumption to be a tenable one, the stock is then only an indirect cause of greater susceptibility.

MISCELLANEOUS FRUIT NOTES

WM. STUART

During the past three seasons more or less extended notes and observations have been made on the fruit trees growing in the station orchard. These have had to do mainly with a study of the flowering and fruiting periods of plums and cherries, the data being taken partly for station purposes and partly for the use of the Division of Pomology of the United States Department of Agriculture.

While the observations are by no means complete, they are in some respects sufficiently so to permit of some comparisons as to dates of flowering and of ripe fruit during the past three seasons,—1903 to 1905 inclusive. The observations made were upon the date of first and full bloom, when leaves began to unfold, formation of terminal bud, first and last picking, together with other data not included in tables I and II. In the case of the Gov. Wood, Montmorency (large) and Montmorency (ordinary), the lack of data is due to the fact that the trees were planted in 1903.

TABLE I. RECORD OF BLOSSOMING AND RIPENING PERIOD OF PLUMS
1903, 1904, 1905

Variety	Date terminal buds form		Date first picking			Date last picking		
	1903	1904	1903	1904	1905	1903	1904	1905
Abundance	June 26	July 1	....	....	Aug. 19	....	....	Aug. 20
American Eagle	....	" 7	....	Sept. 1	Sept. 18	....	Sept. 9	....
Arctic	Aug. 17	June 16	Aug. 12	Aug. 17	Aug. 20	Aug. 22	Aug. 23	Sept. 6
Bixby	" 4	" 24	Sept. 4	....	Sept. 6	Sept. 4	....	" 17
Blackhawk	" 4	July 7	" 2	" 1	" 11	" 4	" 9	" 18
Botan X *Brit.	" 17	June 16	Aug. 7	Aug. 9	Aug. 21	Aug. 15	Aug. 17	Aug. 29
Burbank	" 17	July 21	" 15	" 23	Sept. 1	" 22	" 23	Sept. 11
Chabot	....	" 1	....	" 25	" 5	....	....	" 18
Cheney	" 4	June 24	....	" 25	" 6	....	Sept. 6	" 11
Communia	" 17	July 1	" 29	" 27	" 11	Sept. 7	Aug. 27	" 18
Czar	" 4	June 24	" 1	" 5	Aug. 21	Aug. 8	" 9	Aug. 22
De Soto	" 17	July 7	" 15	....	Sept. 18	" 22	....	....
Forest Garden	" 17	" 29	Sept. 1	....	" 11	Sept. 12	....	....
Gold	....	" 7	....	Sept. 12	" 15	....	Sept. 20	Sept. 18
Green Gage	....	....	....	....	" 15	....	....	" 22
Hawkeye	" 4	" 7	Sept. 4	Aug. 30	" 15	Sept. 12	" 9	" 18
Hung. Prune No. 1	" 17	June 24	Aug. 26	....	" 11	Aug. 26	....	" 18
Keith	June 26	July 7	Sept. 1	Sept. 6	Aug. 26	Sept. 9	" 10	....
Leipsic Riga	Aug. 17	June 16	Aug. 22	....	Sept. 6	" 4	....	" 18
Lombard	June 26	" 16	" 22	Aug. 27	" 8	" 4	" 1	" 18
Milton	Aug. 17	July 21	" 12	" 25	....	Aug. 15	Aug. 25	....
Prairie Flower	" 17	" 15	....	....	....	....	....	....
Prince of Wales	" 4	June 16	" 18	" 25	Aug. 29	Aug. 18	" 30	" 8
Rockford	" 17	July 7	....	" 25	Sept. 8	....	" 30	" 11
Smith's Red	....	" 7	....	Sept. 12	Oct. 8	....	Sept. 20	Oct. 15
Stoddard	" 17	" 7	Sept. 4	" 9	Sept. 15	Sept. 12	" 10	Sept. 18
Whitaker	" 4	Aug. 10	Aug. 15	....	Aug. 2	" 1	....	" 1

TABLE II. RECORD OF BLOSSOMING AND RIPENING PERIOD OF CHERRIES

Variety	Date terminal buds form		Date first picking			Date last picking		
	1903	1904	1903	1904	1905	1903	1904	1905
Bessarabian	June 25	July 1	....	June 23	July 12	....	....	July 19
Brusseler Braune	" 25	June 24	June 18	....	" 3	....	....	" 7
Dyehouse	....	July 1	....	" 26	June 29	....	....	" 3
Early Richmond	" 25	June 25	" 18	July 1	" 29	June 29	....	" 3
English Morello	" 25	July 1	July 1	" 4	July 12	July 4	July 12	" 22
Gov. Wood	....	" 10	....	....	....	....	....	....
George Glass	" 25	" 6	....	....	" 5	....	....	" 12
Griotte du Nord	" 25	....	June 18	....	" 3	....	....	" 12
Juneat Amarelle	" 25	" 1	July 1	....	June 29	....	....	" 19
Late Morello	" 25	" 1	" 9	July 9	July 12	....	" 12	" 26
Lutovka	" 25	" 7	June 18	June 24	June 29	" 9	....	" 7
†Mont. (large)	....	" 7	....	....	....	....	....	....
†Mont. (ord.)	....	" 7	....	....	July 8	....	....	" 12
Ostheim	" 25	" 7	July 1	July 1	" 5	....	....	" 12
Spate Amarelle	" 25	" 1	" 1	" 1	July 7	....	....	" 22
Straus Weichsel	" 25	" 7	June 18	June 24	June 29	....	" 9	" 5
Wragg	" 25	" 1	July 1	July 1	July 12	" 9	" 12	" 22

*Brittlewood. †Montmorency.

RECORD OF BLOSSOMING AND LEAVING OUT PERIOD OF PLUMS

Variety	Date of first bloom in May			Date of full bloom in May			Date leaf buds begin to open in May		
	1903	1904	1905	1903	1904	1905	1903	1904	1905
Abundance,	10	10	13	12	14	14	1	9	8
Am. Eagle,	..	13	15	..	14	17	..	8	11
Arctic (Moore's),	6	13	14	10	15	17	1	9	11
Bixby,	4	15	16	10	17	18	4	9	13
Blackhawk,	8	12	15	10	14	17	1	9	12
Botan X Brittlewood,	5	10	13	8	12	16	3	9	12
Burbank,	5	10	12	9	15	14	2	9	12
Chabot,	..	12	14	..	17	17	..	11	10
Cheney,	8	10	13	10	12	16	5	9	13
Communia,	7	13	14	10	14	16	5	10	12
Czar,	6	11	15	8	13	19	5	9	8
De Soto,	8	13	14	10	14	16	5	9	13
Forest Garden,	9	12	16	11	14	17	3	9	13
Gold,	..	13	15	..	15	18	..	9	8
Green Gage,	..	..	13	..	..	16	..	..	10
Hawkeye,	9	13	16	10	14	17	5	10	14
Hung. Prune, No. 1,	10	14	17	11	17	24	4	9	13
Keith,	8	12	15	10	14	16	..	9	11
Leipsic Riga,	9	14	16	11	16	19	5	9	12
Lombard,	5	12	13	9	14	16	4	10	12
Milton,	11	15	22	13	20	27	2	9	8
Prairie Flower,	10	14	14	12	15	16	3	8	12
Prince of Wales,	9	11	13	11	13	14	*30	7	8
Rockford.	9	13	16	10	14	17	2	8	12
Smith's Red,	10	14	18	12	17	24	3	9	12
Stoddard,	8	14	16	10	17	17	4	9	14
Whitaker,	5	12	15	11	15	18	2	8	10

*April.

RECORD OF BLOSSOMING AND LEAVING OUT PERIOD OF CHERRIES

Variety	Date of first bloom in May			Date of full bloom in May			Date leaf buds begin to open in May		
	1903	1904	1905	1903	1904	1905	1903	1904	1905
Bessarabian,	7	12	12	11	17	13	1	8	8
Brussler Braune,	5	11	14	10	14	16	2	8	8
Dyehouse,	7	14	14	10	15	16	..	10	12
Early Richmond,	7	12	14	10	15	17	4	9	12
English Morello,	9	12	15	11	14	17	3	9	12
Gov. Wood,	..	..	14	..	..	16	..	9	8
George Glass,	7	14	14	11	18	16	3	10	10
Griotte du Nord,	8	..	14	11	..	16	3	..	12
Juneat Amarelle,	8	12	14	11	15	17	4	10	12
Late Morello,	9	12	14	11	17	17	4	10	12
Lutovka,	7	12	14	11	15	16	4	10	12
Montmorency (large),	..	..	15	..	..	17	..	10	12
Montmorency (ord.),	..	14	15	..	17	18	..	10	12
Ostheim,	7	12	14	11	14	17	4	12	13
Spate Amarelle.	9	12	14	11	15	17	4	10	10
Straus Weichsel,	6	11	13	10	14	16	2	8	8
Wragg,	9	13	16	11	15	18	4	10	13

Explanation of the 1903 data is necessary in order to enable the reader to understand some of its discrepancies. As will be remembered, the season of 1903 was an unusual one. The average temperature for March was much higher than normal, a condition which resulted in hastening the development of both leaf and fruit buds. The month of April was much cooler than common, which

somewhat retarded growth, but not sufficiently to prevent a sharp freeze, which occurred early in May, catching most of the fruit trees either in full bloom or with the blossom buds sufficiently far advanced to make them easily susceptible to injury. This resulted in the destruction of a large percent of the flower pistils. This injury reached 100 percent in some varieties. In only a few instances was a full crop of either plums or cherries secured. These untoward temperature conditions were accompanied by an unprecedented drought which lasted from mid-April to mid-June. From this time onwards, however, the rainfall was rather above normal, which induced a secondary growth of the trees. As a result of these unfavorable conditions growth ceased much earlier than usual, the terminal buds being formed earlier than the notes indicate, except where dates are unusually late, this being especially true of the cherries, in which no secondary growth occurred. The later dates mentioned are those on which the terminal buds were formed on the second growth shoots.

While the winter of 1903-04 was an unusually severe one, the climatic conditions of the growing season of 1904 as a whole favored the normal development of the trees. Hence the 1904 data on terminal bud development more closely represents normality. In 1905, because of the writer's illness, as well as because of press of other duties, the dates of terminal bud formation were not secured.

Fairly complete data have been secured on the flowering and fruiting period of the varieties under observation. A comparison of the flowering period data shows at a glance that the season of 1903 was considerably earlier for most varieties than were the two which followed. For example, Burbank showed first bloom on May 5 in 1903, on May 10 in 1904, and on May 12 in 1905. The first pickings of ripe Burbank fruit were made on August 15, 1903, August 23, 1904, and September 1, 1905. The difference in flowering periods was one of seven days, and in fruiting periods of seventeen days. Arctic (*Moore's*) (Domestica) showed first bloom on May 6 in 1903, on May 13 in 1904, and on May 14 in 1905; while first picking of ripe fruit was made on August 12, 1903, August 17, 1904, and August 20, 1905, a difference of eight days in each case. In most cases the relationship between early bloom and date of fruiting holds good; the difference, of course, being greater in some cases than in others. The outcome with cherries is practically the same. Taking the Early Richmond cherry as an example, we find the dates of first bloom to be May 7, 12 and 14, differences of five and seven days; of first picking, June 18, July 1, June 29, differences of thirteen and eleven days. With the English Morello the relative differences between time of blooming and fruiting are approximately maintained.

Summary.—A careful study of the data presented shows that there is a close relationship between time of flowering and time of fruiting, this relationship being quite uniformly maintained during the three seasons noted.

Desirable varieties.—The following varieties upon which observations have been made either in the Station orchards or elsewhere, are deemed most desirable, the judgment being based upon hardiness, prolificacy and quality:

Plums.—Lombard and Arctic (*Moore's*) (Domestica), Burbank and Abundance (Japanese), Milton, Whitaker and Wooten (Wild Goose), Stoddard, Cheney and Hawkeye (Americana).

Cherries—Early Richmond, English Morello, Brusseler Braune, Wragg and Bessarabian.

INSECTS OF THE YEAR

WM. STUART

Although there was no serious outbreak of injurious insects during the present season, a considerable number of inquiries were received concerning leaf eating and sucking insects. For the most part these inquiries were accompanied by living specimens, and when caterpillars or worms were sent, the query was frequent as to the likelihood of their proving to be the larvæ of the brown tail or gypsy moths. No authenticated cases of the presence of either of these two insect pests have been reported to the Station, and it is doubtful if either has as yet invaded the State. It is desirable, however, that all who are in doubt regarding the identity of any unfamiliar pest should send specimens to the Station for examination. The devastation wrought by these moths in Massachusetts should incite all residents of Vermont to take such precautionary measures as are practicable to guard against their introduction within our borders, a contingency which in the case of the brown tail is far from being a remote one.

Many specimens of the red-humped apple worm (*Oedemasia concinna*) were received. Others sent in more or less frequently were the yellow-necked apple tree worm (*Datana ministra*); a species of Halisodota; oyster-shell bark-louse (*Mytilaspis pomorum*); wooly aphis (*Schizoneura sp.*) and plant lice. Another insect not reported, the apple leaf miner (*Tischeria malifoliella Clem.*) was found in abundance in one of the Station orchards.

RED-HUMPED APPLE WORM

This insect, which has been hitherto discussed in publications of this Station,[1] seems to have been quite abundant during the present season. It is easily recognized by its coral-red head and similarly colored hump on the back of its first abdominal segment. As a rule these insects are not considered a dangerous orchard pest, although when present in large numbers they do a considerable amount of injury. The usual remedies against leaf-eating insects, —spraying the foliage with some arsenical poison,—will serve to keep them in check.

YELLOW-NECKED APPLE TREE WORM

This particular insect does not appear to have been generally distributed over the State or to have done any considerable damage to either fruit or forest trees. Like the red-humped apple worm, the larvæ feed in colonies, are very voracious, and when present in sufficient numbers cause considerable injury to the tree. It may be as successfully combatted with arsenites as is its red-humped fellow.

HALISODOTA SP.

The larvæ of the Halisodota were clothed with dense tufts of finely-barbed white hairs. They were rather small, about one-half inch in length, and were generally sent in under the apprehension that they were larvæ either of the brown tail or of the gypsy moth. So far as known these insects have never occurred in sufficient numbers to prove troublesome to fruit or shade trees. They may be controlled in the same manner as the first two mentioned.

WOOLY APHIS

These insects are more frequently found on young apple trees than elsewhere. They occur on the tips of young shoots, in crevices in the bark of the trunk, or in the scars caused by pruning. In such places they congregate in colonies. Their feeding habits in many respects are very similar to those of the ordinary plant lice from which they differ mainly in that they are covered with a light ash-grey wooly-like substance. When present in large numbers they undoubtedly cause much injury to the young fruit trees. As they are sucking and not chewing insects, the remedies to be employed are entirely different from that cited above. Contact insecticides like kerosene emulsion, tobacco liquid, whale-oil soap, etc., are the only effective methods of combating this class of pests.

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[1] Vt. Sta. Bul., 60, p. 4 (1897).

OYSTER-SHELL BARK LOUSE

The wide distribution of this scale insect in Vermont has been noted in a former publication which has long been out of print,[1] in which a somewhat complete account of its life history and habits is given and methods of controlling it discussed. Specimens are so frequently received and it is so generally prevalent throughout the State, that additional attention seems worth while.

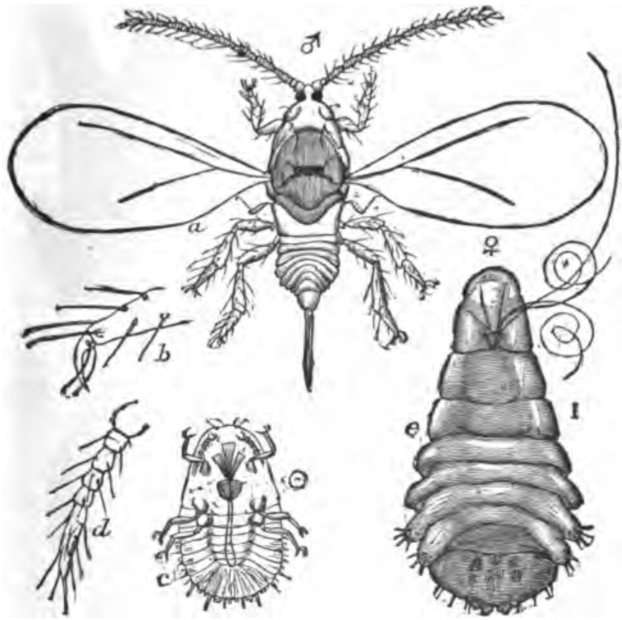

Fig. 1. Oyster-shell bark louse, (a) adult male, (b) foot, (c) larva, (d) antenna of larva, (e) adult female. All very greatly enlarged. (L. O. Howard).

The injury occasioned by the oyster-shell bark louse is, of course, directly proportional to its numbers. When trees are badly infested the drain made by these sucking insects upon the tree is a serious one, and may often result in its death. The oyster-shell bark louse is readily distinguishable from other scale insects by its elongated, rather slender curved form, being about one-eighth inch in length.

Remedies.—Two courses may be pursued in its eradication,—the scales may be attacked during the dormancy of the tree, or the newly-

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[1]Perkins, Vt. Sta. Bul. 60, pp. 9-12 (1897).

hatched larvæ may be dealt with while the tree is in full leaf. Treatment by the first method necessitates the application of an insecticide having sufficient caustic properties to destroy the eggs beneath the scales; that by the latter scheme is less drastic in that the newly-hatched larvæ, unprotected by a scale, are easily injured by more dilute caustic substances.

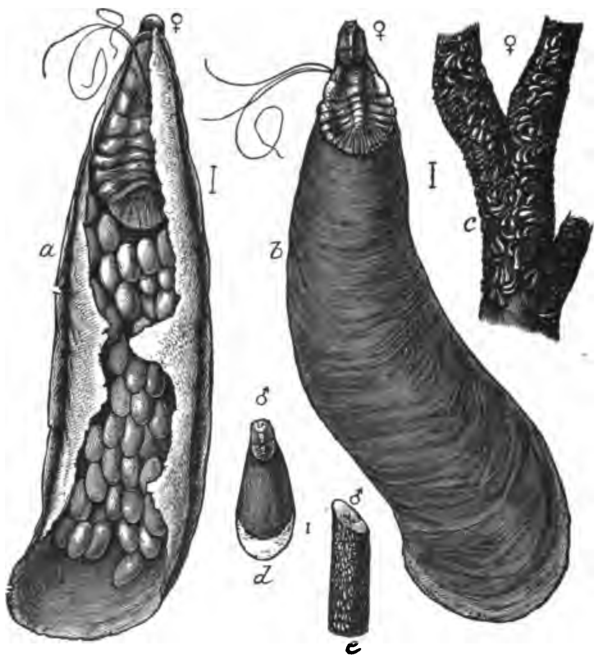

Fig. 2. Oyster-shell bark louse, (a) scale with female and eggs seen from below, (b) same from above, (c) female scales on the twig, (d) male scale from above, (e) male scales on the twig. All greatly enlarged. The lines at the right of the figures show natural size. (L. O. Howard).

The most effective insecticide yet employed against the oyster-shell bark louse during the dormant period of the tree is the lime-sulphur, or lime-sulphur-salt wash. An application of this wash during the latter part of March or first weeks in April, followed in the case of badly infested trees by a second application before the buds have swollen much, will generally suffice to eradicate the scale. Such treatment is also one of the most effective agents in destroying the apple scab fungus spores.

The larvæ of the oyster-shell bark louse usually hatch out in this latitude about the first week in June. The newly-hatched insect appears as a small grey or brownish-grey speck on the surface of the bark, and is not readily recognized by the unaided eye as a living organism. When in this stage of their development, or even a little later, an application of kerosene emulsion diluted to one part to fifteen of water, proves quite effective, and, if properly made, can be applied to the small twigs as well as the body and large branches of the tree without fear of leaf injury.

THE APPLE LEAF MINER (*Tischeria malifoliella Clem.*)

Towards the close of the present season rather unusual brownish or rusty appearance of foliage of some old apple trees in one of the station orchards led to a closer examination, which revealed the presence of an immense number of leaf miners. These insects were identified by the Bureau of Entomology of the United States Department of Agriculture as *Tischeria malifoliella Clem.* A somewhat careful survey of the entire orchard showed that with few exceptions practically every leaf was infested with the larvæ of this insect. How they came to be so abundant the present season without having been previously noted, the writer is unable to say.

As a rule this apple leaf miner is not considered a serious pest. It is known to occur on the apple, crab apple, raspberry and blackberry. So far as the writer is aware, there is but one record of its having occasioned serious injury to cultivated fruits. Lyons[1] reports them as causing serious damage to a blackberry plantation. The injury to the infested trees in the station orchard was quite marked. It was evidenced by the unhealthy appearance of the foliage, its premature loss,—the leaves falling from two to three weeks earlier than they normally should—and by the lack of development of the fruit, both in size and quality.

As this insect seems not to have been reported by the fruit growers of the State, it would be interesting to know whether any such leaf injury has been observed. The following brief description of the insect may serve as a guide to its detection another year: The larvæ when full grown are about one-fourth of an inch in length and about one-sixteenth of an inch in diameter, tapering gently from the head to the anal extremity. They are footless and of a light yellowish green color with a brownish-black head. The newly-hatched larvæ tunnels its way between the two epidermal layers of the leaf, eating away the

[1]Mich. Sta. Bul., 129, p. 12 (1896).

soft connective tissue, making a sort of thread-like passage at first which it gradually enlarges into a sort of trumpet-shaped mine. Owing to this characteristic shape it is sometimes called the trumpet leaf-miner. Very frequently the mines are greatly enlarged and when many miners are present in a single leaf the mines fuse into one another, thereby practically involving the whole connective tissue of the leaf. When fully developed the larvæ begins to pull in the opposite edges of the mine until it causes a fold in the leaf, after which the tiny cavity is well lined with silk preparatory to the transformation to the pupal stage. It passes the winter in the leaf and emerges some time in May as a small grey moth, measuring a little over a quarter of an inch from tip to tip of its expanded wings. The moths soon mate and the female begins depositing its eggs, thus completing its life cycle.

Distribution.—The apple leaf miner was reported in New York by Brunn[2] in 1883; by Weed[3] in Illinois in 1889; by Lyon[4] in Michigan in 1896; by Lugger[5] in Minnesota in 1899; and by Petit[6] in Michigan in 1899.

Remedies.—As the larvæ work beneath the epidermis of the leaf they are not amenable to insecticidal treatment, either with arsenical or caustic solutions; hence such measures as may be employed for their suppression must be preventive rather than remedial. Lyons mentions picking off and destroying infested blackberry leaves, and the destruction of all fallen leaves, but makes no further report of the efficacy of this treatment. The destruction of the fallen leaves from infested trees or brambles, whenever it occurs in sufficient numbers to justify such procedure, is, so far as the writer knows, the only feasible plan of controlling this insect.

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[2]Cornell Sta. Rpt., 2, pp. 155-6 (1883).
[3]Rpt. State Entomol. Ill. 15 (1889).
[4]Loc. cit.
[5]Minn. Sta. Bul., 61, pp. 316-17 (1899).
[6]Mich. Sta. Bul., 180, pp. 251-3 (1899).

MAPLE SYRUP AND MAPLE SUGAR INVESTIGATIONS WITH PARTICULAR REFERENCE TO THE DETECTION OF ADULTERATION

C. H. JONES

The problem of the detection of cane sugar when added to pure maple products has been studied as time permitted for four years past. Many samples of maple syrup and sugar, both pure and adulterated, have been examined with the view of establishing standards whereby the pure article could be distinguished from the sophistication so freely offered to the purchasing public. The results obtained are set forth in the following pages, together with such statements as to methods employed and explanatory data as seem necessary.[1]

The chemical identity of the sugars derived from maple, cane, beet, etc., has until recently been deemed a sufficient bar to any successful attempt to differentiate between them. The manufacturers of spurious maple goods have not failed to take advantage of this fact to such an extent that conservative estimates indicate that only 15 to 20 percent of all the so-called maple syrup and sugar on the market is true to name.

But it is in other ways than by a mere estimation of the sugar content that the adulteration of maple goods is to be detected. "Maple sugar is a crude product which from the nature of the case it is impracticable to refine. Neither is such refining desirable, for the peculiar value of maple goods is due, not to their sugar content or sweetness, but rather to the agreeable 'maple flavor' that accompanies them. Too much refining eliminates this flavor, and then the value of the goods is no greater than that of ordinary granulated or brown sugar."[2] In other words the clarification, by chemicals, bone black filtration, centrifuge and drainage, to which ordinary sugars are subjected, is never used in the production of pure maple goods, which only receive an occasional skimming off of coagulated organic impurities as the maple sap is boiled, care to prevent burning, and a final removal of the malate of lime, which forms when a sufficient concentration is reached, by sedimentation or by filtering the hot syrup through flannel.

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[1]An early bulletin of this Station, No. 26, treats of maple sugar manufacture; a recent one, No. 103, deals with the physiological and chemical phases of the maple sap flow; while the 17th report briefly outlines methods used in detecting adulteration in maple products.

[2]Vt. Sta. Rpt., 17, p. 447 (1904).

"Pure maple products and those adulterated with cane sugar seem most clearly differentiated by the varying amounts and nature of their ash contents. Only a trace of ash is found in refined cane sugar, while in maple sugar a much larger quantity is normally present. Commercial brown sugar may also carry a considerable ash content, but its character is so distinct from that found in the maple that mere similarity in amount of ash does not seriously interfere with its detection."[1]

Malic acid combined with lime, potash, soda, etc., is a normal constituent of maple sap and consequently is in part retained in the maple syrup or concrete. Its identification and estimation is therefore a valuable guide where questions of purity are concerned, as ordinary granulated or brown sugars contain, if any, but traces of malic acid.

The analyses in Tables I to X show the ash contents, malic acid value and lead subacetate precipitate, together with other subsidiary data, of pure and adulterated maple syrups and sugars, as well as results obtained from the examination of commercial brown sugar, beet sugar, raw cane sugar and sundry other products.

Results are reported under headings as seen in the following outline:

(A) Total ash, percent.
(B) Soluble ash, percent.
(C) Insoluble ash, percent.
(D) Alkalinity of soluble ash, expressed as cubic centimeters of tenth normal hydrochloric acid for ash of 1 gram of sample. Methyl orange indicator.
(E) Alkalinity of insoluble ash, expressed as cubic centimeters of tenth normal hydrochloric acid for ash of 1 gram of sample. Methyl orange indicator.
(F) Ratio of insoluble ash to soluble ash: $B \div C$.
(G) Alkalinity of 1 gram soluble ash: $(D \times 100) \div B$.
(H) Alkalinity of 1 gram insoluble ash: $(E \times 100) \div C$.
(I) Ratio 1 gram insoluble alkalinity to 1 gram soluble alkalinity: $G \div H$.
(J) Percent of ash, soluble: $(B \times 100) \div A$.
(K) Lead subacetate precipitate.
(L) Malic acid value.

The letters in the column headed character refer mainly to quality as regards color. Thus L, indicates light colored; M, medium; and P, poor, dark colored material; conditions which are dependent on the care used in manufacture, soil, seasonal differences, etc.

[1]Vt. Sta. Rpt., 17, p. 447 (1904).

TABLE I. PURE MAPLE SYRUP[1]

No.	Character	A	B	C	D	E	F	G	H	I	J	K	L
102	L	0.56	0.40	0.16	0.46	0.44	2.5	115	275	0.5	71	1.00	0.49
103	L	0.60	0.37	0.23	0.48	0.58	1.6	130	252	0.5	62	1.35	0.63
104	L	0.57	0.40	0.17	0.46	0.44	2.4	115	259	0.4	74	1.30	0.45
105	L	0.50	0.34	0.16	0.46	0.46	2.1	135	287	0.5	68	1.70	0.50
106	L	0.51	0.34	0.17	0.48	0.42	2.0	141	247	0.6	67	....	0.48
94	L	0.52	0.30	0.22	0.48	0.52	1.4	160	236	0.7	58	1.55	0.47
107	L	0.54	0.34	0.20	0.50	0.56	1.7	147	280	0.5	63	1.20	0.51
109	L	0.63	0.39	0.24	0.56	0.59	1.6	144	246	0.6	62	1.90	0.53
110	L	0.63	0.41	0.22	0.59	0.60	1.9	144	273	0.5	65	1.50	0.56
99	L	0.64	0.42	0.22	0.64	0.52	1.9	152	236	0.6	66	1.10	0.54
111	L	0.67	0.40	0.27	0.60	0.68	1.5	150	252	0.6	60	1.40	0.51
112	M	0.61	0.37	0.24	0.56	0.56	1.5	151	233	0.6	61	1.90	0.54
114	L	0.53	0.35	0.18	0.48	0.36	1.9	137	200	0.7	66	1.40	0.44
115	L	0.53	0.35	0.18	0.51	0.37	1.9	146	206	0.7	66	1.00	0.42
97	L	0.54	0.38	0.16	0.53	0.47	2.4	139	294	0.5	70	....	0.46
116	M	0.52	0.36	0.16	0.60	0.36	2.3	167	225	0.7	69	0.90	0.44
117	L	0.58	0.37	0.21	0.56	0.48	1.8	151	229	0.7	64	1.30	0.59
119	M	0.69	0.36	0.33	0.46	0.65	1.1	128	197	0.6	52	1.90	0.47
120	M	0.60	0.40	0.20	0.51	0.48	2.0	127	240	0.5	67	1.40	0.45
121	M	0.56	0.35	0.21	0.45	0.60	1.7	129	286	0.5	63	1.70	0.49
122	P	0.86	0.35	0.51	0.46	0.94	0.7	131	184	0.7	41	2.60	0.72
125	M	0.50	0.34	0.16	0.47	0.36	2.1	138	225	0.6	68	1.25	0.46
126	M	0.58	0.42	0.16	0.48	0.37	2.6	114	231	0.5	72	1.00	0.47
93	P	0.68	0.32	0.37	0.53	0.84	0.9	166	233	0.7	47	1.95	0.62
127	P	0.58	0.34	0.24	0.50	0.62	1.4	147	258	0.6	59	1.80	0.56
128	P	0.62	0.35	0.27	0.58	0.60	1.3	166	222	0.7	57	1.50	0.52
130	M	0.51	0.31	0.20	0.52	0.43	1.6	168	215	0.8	61	1.50	0.51
131	M	0.53	0.37	0.16	0.56	0.46	2.3	151	287	0.5	70	1.20	0.58
132	M	0.57	0.30	0.27	0.50	0.62	1.1	167	230	0.7	53	1.50	0.54
133	P	0.61	0.39	0.22	0.53	0.54	1.8	136	245	0.6	64	1.85	0.68
134	P	0.64	0.41	0.23	0.50	0.60	1.8	122	261	0.5	64	1.70	0.61
135	P	0.66	0.42	0.24	0.60	0.56	1.8	143	233	0.6	64	1.65	0.62
69	L	0.73	0.47	0.26	0.48	0.56	1.8	102	215	0.5	64	....	....
70	M	0.64	0.39	0.25	0.39	0.56	1.6	100	224	0.4	61	....	....
71	L	0.61	0.43	0.18	0.39	0.46	2.4	91	256	0.4	71	....	....
72	L	0.65	0.40	0.25	0.49	0.54	1.6	123	216	0.6	62	....	....
63	L	0.58	0.32	0.26	0.30	0.66	1.2	94	294	0.3	55	....	....
64	L	0.62	0.38	0.24	0.42	0.51	1.6	111	213	0.5	61	....	....
65	M	0.65	0.46	0.19	0.51	0.56	2.4	111	295	0.4	71	....	....
66	M	0.63	0.44	0.19	0.48	0.57	2.3	109	300	0.4	70	....	....
137	L	0.64	0.46	0.18	0.60	0.54	2.6	130	300	0.4	72	....	....
139	M	0.56	0.32	0.24	0.48	0.66	1.3	150	275	0.5	57	....	....
143	M	0.65	0.38	0.27	0.60	0.56	1.4	158	207	0.7	59	....	....
145	M	0.69	0.47	0.22	0.66	0.61	2.1	140	277	0.5	68	....	....
146	L	0.55	0.29	0.26	0.50	0.67	1.1	172	258	0.7	53	1.40	....
147	L	0.54	0.35	0.19	0.44	0.45	1.8	126	237	0.5	65	1.00	0.41
149	L	0.77	0.47	0.30	0.63	0.59	1.6	134	197	0.7	61	2.40	0.46
155	L	0.64	0.42	0.22	0.60	0.49	1.9	143	223	0.6	66	1.50	0.59
Maximum,		0.86	0.47	0.51	0.66	0.94	2.6	172	300	0.7	74	2.60	0.72
Minimum,		0.50	0.29	0.16	0.30	0.36	0.7	91	184	0.3	41	0.90	0.41
Average,		0.60	0.38	0.22	0.51	0.54	1.7	134	245	0.5	63	1.51	0.53

[1]See explanation as to headings A to L on page 316.

TABLE II. PURE MAPLE SUGAR[1]

No.	Character	A	B	C	D	E	F	G	H	I	J	K	L
6	L	0.76	0.42	0.34	0.54	0.78	1.2	129	229	0.6	55		
7	L	0.92	0.50	0.42	0.58	0.88	1.2	116	210	0.6	54		
8	L	0.76	0.42	0.34	0.44	0.80	1.2	105	235	0.4	55		
9	L	0.76	0.41	0.35	0.56	0.80	1.2	137	229	0.6	54	2.60*	0.65*
10	L	0.74	0.46	0.28	0.54	0.70	1.6	117	250	0.5	62		
11	L	0.71	0.42	0.29	0.60	0.74	1.5	143	255	0.6	59		
12	L	0.78	0.40	0.38	0.62	0.92	1.1	152	242	0.6	51		
1	L	0.87	0.51	0.36	0.56	0.60	1.4	110	166	0.7	59		
2	M	0.83	0.48	0.35	0.44	0.67	1.4	92	171	0.5	58		
3	L	0.94	0.52	0.42	0.68	0.88	1.2	131	209	0.6	55	3.30*	0.75*
4	L	1.01	0.51	0.50	0.74	0.96	1.0	145	192	0.8	50		
5	L	1.04	0.49	0.55	0.66	0.98	0.9	131	178	0.7	47		
13	M	0.92	0.45	0.47	0.58	0.82	1.0	129	174	0.7	49		
14	M	0.70	0.36	0.34	0.52	0.65	1.1	144	191	0.8	51		
15	P	1.16	0.50	0.66	0.62	1.31	0.8	124	198	0.6	43	3.80*	0.84*
16	P	1.10	0.45	0.65	0.68	1.11	0.7	151	171	0.9	41		
17	M	1.11	0.49	0.62	0.79	1.04	0.8	161	168	1.0	44		
18	M	1.05	0.42	0.63	0.61	1.08	0.7	145	171	0.8	40		
19	P	0.80	0.46	0.34	0.56	0.77	1.4	122	226	0.5	58		
20	M	1.00	0.59	0.41	0.68	0.90	1.4	115	220	0.5	59		
21	P	0.94	0.47	0.47	0.64	1.04	1.0	136	221	0.6	50	2.60*	0.78*
22	P	0.94	0.42	0.52	0.56	0.98	0.8	133	188	0.7	45		
23	P	0.82	0.42	0.40	0.60	0.84	1.1	143	210	0.7	50		
24	P	0.88	0.46	0.42	0.64	0.88	1.1	139	210	0.7	52		
31	L	0.73	0.50	0.23	0.53	0.59	2.2	106	257	0.4	69	....	....
32	L	0.90	0.60	0.30	0.66	0.76	2.0	110	253	0.4	67	....	....
33	L	0.64	0.44	0.20	0.40	0.55	2.2	91	275	0.3	69	....	....
35	M	0.87	0.47	0.40	0.62	0.86	1.2	132	215	0.6	54	....	....
36	P	1.32	0.45	0.87	0.44	1.72	0.5	98	198	0.5	34	....	....
37	L	0.99	0.63	0.36	0.60	0.90	1.8	95	250	0.4	64	....	....
38	L	1.13	0.51	0.62	0.45	1.51	0.8	88	244	0.4	45	....	....
39	M	0.86	0.48	0.38	0.51	0.84	1.3	106	221	0.5	56	....	....
40	M	0.93	0.55	0.38	0.54	0.91	1.5	98	239	0.4	59	....	....
41	M	0.82	0.46	0.36	0.64	0.90	1.3	139	250	0.6	56	....	....
42	M	1.06	0.52	0.54	0.70	1.10	1.0	135	204	0.7	49	....	....
43	M	1.22	0.58	0.64	0.80	1.50	0.9	138	234	0.6	48	....	....
44	M	1.11	0.63	0.48	0.60	1.10	1.3	95	229	0.4	57	....	....
47	M	0.96	0.48	0.48	0.66	0.84	1.0	138	175	0.8	50	....	....
157	M	0.84	0.52	0.32	0.76	0.77	1.6	146	241	0.6	62	....	....
158	M	0.69	0.38	0.31	0.64	0.70	1.2	168	226	0.7	55	....	....
159	M	0.87	0.56	0.31	0.74	0.86	1.8	132	277	0.5	64	....	....
153	L	0.79	0.52	0.27	0.70	0.65	1.9	135	241	0.6	66	....	0.73
151	M	0.95	0.59	0.36	0.77	0.86	1.6	131	239	0.6	62	....	0.81
Maximum,		1.32	0.63	0.87	0.80	1.72	2.2	168	277	1.0	69	3.80	0.84
Minimum,		0.64	0.36	0.20	0.40	0.55	0.5	88	166	0.3	40	2.60	0.65
Average,		0.91	0.48	0.43	0.61	0.91	1.1	127	211	0.6	53	3.03	0.75

*The composite samples used for securing the data in columns K and L are respectively numbered 180, 181, 182 and 183. See Table IX.

TABLE III. ADULTERATED MAPLE SYRUP[1]

No.	A	B	C	D	E	F	G	H	I	J
142	0.35	0.25	0.10	0.35	0.27	2.5	140	270	0.5	71
85	0.49	0.36	0.13	0.34	0.38	2.8	94	292	0.3	74
86	0.31	0.20	0.11	0.27	0.36	1.8	135	327	0.4	65
87	0.26	0.16	0.10	0.27	0.27	1.6	169	270	0.5	62
200	0.28	0.16	0.12	0.24	0.28	1.3	150	233	0.6	57
203	0.76	0.70	0.06	0.90	0.14	11.7	129	233	0.6	92
204	0.54	0.49	0.05	0.62	0.05	9.8	126	100	1.3	91
205	0.44	0.42	0.02	0.57	0.06	21.0	136	300	0.4	95
206	0.54	0.48	0.06	0.80	0.04	8.0	167	67	2.5	89

[1]See explanation as to headings A to L on page 316.

TABLE IV. ADULTERATED MAPLE SUGAR[1]

No.	A	B	C	D	E	F	G	H	I	J
82	0.28	0.13	0.15	0.08	0.21	0.9	62	140	0.4	46
83	0.42	0.20	0.22	0.32	0.42	0.9	160	191	0.8	48
84	0.25	0.19	0.06	0.26	0.18	3.1	137	300	0.5	76
73	0.30	0.15	0.15	0.08	0.30	1.0	53	200	0.3	50
74	0.24	0.13	0.11	0.06	0.26	1.2	46	236	0.2	54
75	0.16	0.10	0.06	0.04	0.12	1.7	40	200	0.2	63
76	0.32	0.19	0.13	0.20	0.25	1.5	105	192	0.5	59
77	0.38	0.18	0.20	0.20	0.46	0.9	111	230	0.5	47
78	0.31	0.19	0.12	0.30	0.30	1.6	158	250	0.6	61
79	0.48	0.34	0.14	0.30	0.28	2.4	88	200	0.4	71
80	0.33	0.17	0.16	0.20	0.35	1.1	118	219	0.5	52
202	0.26	0.19	0.07	0.26	0.22	2.7	137	314	0.4	73
201	0.98	0.85	0.13	0.58	0.46	6.5	68	354	0.2	87

TABLE V. MISCELLANEOUS PURE MAPLE PRODUCTS[1]

	No.	A	B	C	D	E	F	G	H	I	J
Stirred sugar,	49	1.17	0.61	0.56	0.68	1.14	1.1	111	203	0.5	52
Stirred sugar,	48	1.34	0.69	0.65	0.74	1.28	1.1	107	197	0.5	52
Drained sugar,	50	1.41	0.23	1.18	0.24	1.73	0.2	104	147	0.7	16
Drainings (50),	51	1.11	0.55	0.56	0.71	1.27	1.0	129	227	0.6	50
Drained sugar,	52	1.36	0.26	1.10	0.38	1.82	0.2	146	165	0.9	19
Drainings (52),	53	1.26	0.42	0.84	0.58	1.25	0.5	138	149	0.9	33
Drained sugar,	54	0.74	0.44	0.30	0.46	0.83	1.5	105	283	0.4	59
Drainings (54),	55	1.06	0.82	0.24	0.86	0.68	3.4	105	283	0.4	77
Drained sugar,	57	0.94	0.18	0.76	0.16	1 40	0.2	89	184	0.5	19
Drained sugar,	58	0.86	0.26	0.60	0.26	1.16	0.4	100	193	0.5	30
Drained sugar,	59	1.55	0.28	1.27	0.28	1.60	0.2	100	126	0.8	18
Maple cream,	199	0.79	0.46	0.33	0.72	0.84	1.4	156	254	0.6	58

TABLE VI. CANADIAN PURE MAPLE SUGAR[1]

	No.	A	B	C	D	E	F	G	H	I	J
	25	0.80	0.54	0.26	0.72	0.64	2.1	133	246	0.5	68
	26	0.62	0.36	0.26	0.52	0.64	1.4	144	246	0.6	58
	27	0.73	0.53	0.20	0.48	0.44	2.7	91	220	0.4	73
	28	0.78	0.44	0.34	0.60	0.79	1.3	136	232	0.6	56
	29	0.80	0.51	0.29	0.54	0.64	1.8	106	221	0.5	64
	30	0.84	0.42	0.42	0.58	0.86	1.0	138	205	0.7	50
Average,		0.76	0.47	0.29	0.57	0.67	1.6	121	231	0.5	62

MISCELLANEOUS COMMERCIAL SAMPLES

TABLE VII. DIFFERENT GRADES OF BROWN SUGAR, RAW CANE SUGAR, BEET SUGAR AND GLUCOSE[1]

	No.	A	B	C	D	E	F	G	H	I	J
Brown sugar, dark,	89	4.33	2.74	1.59	0.76	2.34	1.7	28	147	0.19	63
Brown sugar, light,	90	1.44	1.30	0.14	0.48	0.26	9.3	37	185	0.20	90
Brown sugar, med.,	91	2.80	2.15	0.65	0.15	1.18	3.3	77	182	0.04	77
Brown sugar, light,	92	1.06	1.00	0.06	0.30	0.16	16.7	30	267	0.11	94
Brown sugar, light,	100	0.74	0.68	0.06	0.26	0.15	11.3	38	250	0.15	92
Raw cane sugar,	98	0.59	0.41	0.18	0.32	0.46	2.3	78	256	0.30	70
Filtered syp. (98),	189	0.26	0.16	0.10	0.24	0.24	1.6	150	240	0.63	61
Raw cane sugar,	184	0.46	0.23	0.23	0.36	0.52	1.0	157	226	0.69	50
Filtered syp. (184),	187	0.26	0.16	0.10	0.24	0.22	1.6	150	220	0.68	61
Raw cane sugar,	185	0.32	0.10	0.22	0.18	0.42	0.5	180	191	0.94	31
Filtered syp. (185)	188	0.19	0.11	0.08	0.22	0.24	1.4	200	300	0.67	58
Beet sugar (white)	191	0.33	0.31	0.02	0.40	0.02	15.5	129	100	1.29	94
Beet sugar (light)	190	0.86	0.78	0.08	0.38	0.28	9.8	46	350	0.13	91
*Karo,	95	1.03	0.86	0.17	0.40	0.40	5.0	47	235	0.20	84
†Confect's glucose,	96	0.57	0.45	0.12	0.24	0.18	3.8	53	150	0.35	79

*A commercial product said to contain 85 percent corn syrup (glucose), and 15 percent cane syrup.

†Glucose can be detected by other methods and these results are simply given as a matter of interest.

[1]See explanation as to headings A to L on page 316,

TABLE VIII. EFFECT OF BOILING AND FILTERING ON PURE MAPLE SYRUP[1]

	No.	A	B	C	D	E	F	G	H	I	J
	106	0.50	0.32	0.18	0.47	0.43	1.8	147	239	0.6	64
	113	0.64	0.42	0.22	0.61	0.56	1.9	145	255	0.6	66
	97	0.53	0.36	0.17	0.54	0.48	2.1	150	282	0.5	68
	119	0.63	0.34	0.29	0.42	0.58	1.2	124	200	0.6	54
	122	0.74	0.34	0.40	0.42	0.89	0.9	124	223	0.6	46
	131	0.52	0.36	0.16	0.55	0.46	2.3	153	287	0.5	69
	137	0.53	0.36	0.17	0.55	0.42	2.1	153	247	0.6	68
	139	0.51	0.28	0.23	0.42	0.58	1.2	150	252	0.6	55
	143	0.57	0.37	0.20	0.54	0.50	1.9	146	250	0.6	65
	147	0.54	0.36	0.18	0.50	0.46	2.0	139	256	0.5	67
	149	0.61	0.37	0.24	0.56	0.60	1.5	151	250	0.6	61
	155	0.58	0.38	0.20	0.60	0.47	1.9	158	235	0.6	66
Maximum,		0.74	0.42	0.40	0.61	0.89	2.3	158	287	0.6	69
Minimum,		0.50	0.28	0.16	0.42	0.43	0.9	124	200	0.5	46
Average,		0.58	0.36	0.22	0.52	0.54	1.6	147	245	0.6	62
Average original syrups,		0.63	0.38	0.25	0.54	0.57	1.5	142	228	0.6	60

TABLE IX. EFFECT OF DISSOLVING, BOILING AND FILTERING ON PURE MAPLE SUGAR[1]

	No.	A	B	C	D	E	F	G	H	I	J
	19	0.56	0.34	0.22	0.58	0.66	1.6	171	300	0.6	61
	162	0.52	0.34	0.18	0.48	0.55	1.9	141	306	0.5	65
	6	0.50	0.35	0.15	0.42	0.52	2.3	120	347	0.4	70
	172	0.69	0.33	0.36	0.51	0.60	0.9	155	167	0.9	48
	56	0.51	0.33	0.18	0.36	0.39	1.8	109	217	0.5	65
	151	0.67	0.48	0.19	0.66	0.50	2.5	138	263	0.5	72
	153	0.55	0.40	0.15	0.54	0.40	2.7	135	267	0.5	73
	180	0.50	0.33	0.17	0.46	0.44	1.9	139	259	0.5	66
	181	0.53	0.37	0.16	0.48	0.50	2.3	130	312	0.4	70
	182	0.53	0.27	0.26	0.45	0.60	1.0	167	231	0.7	51
	183	0.52	0.37	0.15	0.54	0.44	2.5	146	293	0.5	71
Maximum,		0.69	0.48	0.36	0.66	0.66	2.7	171	347	0.9	73
Minimum,		0.50	0.27	0.15	0.36	0.39	0.9	109	167	0.4	48
Average,		0.55	0.36	0.19	0.50	0.51	1.9	139	268	0.5	65
Average original sugars,		0.94	0.45	0.49	0.58	0.93	0.9	129	190	0.7	49

TABLE X. SUMMARY OF RESULTS EXPRESSED ON DRY MATTER BASIS[1]

SYRUPS. TABLE I

	A	B	C	D	E	F	G	H	I	J	K	L
Maximum,	1.32	0.72	0.78	1.02	1.45	2.6	172	300	0.7	74	4.00	1.11
Minimum,	0.77	0.45	0.25	0.46	0.55	.7	91	184	0.3	41	1.38	0.65
Average,	0.92	0.58	0.34	0.79	0.83	1.7	136	244	0.6	63	2.32	0.82

SUGARS. TABLE II

	A	B	C	D	E	F	G	H	I	J	K	L
Maximum,	1.47	0.70	0.97	0.89	1.91	2.2	168	277	1.0	69	4.22	0.93
Minimum,	0.71	0.40	0.22	0.44	0.61	0.5	88	166	0.3	40	2.89	0.72
Average,	1.01	0.53	0.48	0.68	1.01	1.1	128	210	0.6	53	3.37	0.83

AVERAGE TABLE VIII. FILTERED MAPLE SYRUP

	A	B	C	D	E	F	G	H	I	J	K	L
Filtered syp.,	0.89	0.55	0.34	0.80	0.83	1.6	145	244	0.6	62	...	0.66
Original syp.,	0.97	0.58	0.39	0.83	0.88	1.5	143	226	0.6	60	2.66	0.82

AVERAGE TABLE IX. FILTERED MAPLE SUGAR SYRUP

	A	B	C	D	E	F	G	H	I	J	K	L
Filt'd sug.syp.	0.85	0.55	0.30	0.77	0.78	1.8	140	257	0.5	65	2.29	0.66
Original sug.	1.04	0.50	0.54	0.64	1.03	0.9	128	191	0.7	49	3.37	0.83

[1]See explanation as to headings A to L on page 316.

METHODS OF ANALYSIS

Ash.—Weigh 5 grams of syrup or sugar into a tared platinum dish; heat over asbestos board until the contents are thoroughly carbonized; transfer to a muffle and burn at low red heat to a white or grey ash. Cool in a desicator and weigh quickly. Dissolve the residue in about 40 c. c. of hot water and boil gently for two minutes, using care to avoid spattering. Filter through a small ashless filter and wash with hot water until the filtrate amounts to about 100 c. c. Transfer filter and contents to the original platinum dish and incinerate at low red heat as before. Cool and weigh. Cool and titrate the solution containing the soluble ash with tenth normal hydrochloric acid, using, at first, phenolphthalein as indicator. When the color has disappeared add a drop of methyl orange and complete the titration until total neutrality is reached. Add to the insoluble ash an excess of the tenth normal acid (10 c. c. is usually sufficient) and about 30 c. c. of water. Boil gently until solution is complete. Cool and titrate with tenth normal sodium hydroxide, using methyl orange as indicator. Calculate from the results obtained the percents of total ash, water soluble ash, insoluble ash, and the methyl orange alkalinity of the soluble and insoluble ash, and, if desired, other data as given in the outline on page 316. The phenolphthalein alkalinity mentioned above runs quite uniformly about one-half the methyl orange figure.

Malic acid value.—The results under this head were obtained by using the method of Hortvet,[1] as follows:

"Six and seven-tenths grams of the sample are weighed into a 200 c. c. beaker and water added to make a volume of 20 c. c. The solution is made slightly alkaline with ammonia, 1 c. c. of a 10 percent solution of calcium chloride added, then 60 c. c. of 95 percent alcohol. The beaker is covered with a watch glass and heated for one-half hour on a water bath, when the flame is turned off and beaker left to stand over night. The material in the beaker is then filtered through good quality filter paper, the precipitate washed with hot 75 percent alcohol to freedom from soluble calcium salt, dried and ignited. From 15 to 20 c. c. of tenth normal hydrochloric acid is added to the ignited residue, the lime thoroughly dissolved by careful boiling, and the excess of acid titrated with tenth normal sodium hydroxid, using methyl orange as an indicator. One-tenth of the number of cubic centimeters of acid neutralized expresses the result, which for the present will be called 'malic acid value.'"

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[1]Jour. Amer. Chem. Soc. (1904) 26:1536; also U. S. Dept. Agr., Bu. Chem., Circular 23, p. 7 (1905).

Lead subacetate precipitate.—The method employed in determining this figure originated in this laboratory, and is given below.

A short-cut method has been in use here since 1903, designed quickly to sort out samples that have been seriously adulterated with refined sugar.[1] It is based upon the volume of the precipitate produced in the sugar solution by lead subacetate.[2]

Method.—Five grams of syrup or sugar are weighed into a Purdy sediment tube and dissolved in 10 c. c. of water. Two c. c. of standard lead subacetate solution are now added, the solution mixed, and the tube, placed in a perforated cork, is whirled in an ordinary Babcock machine for four minutes at a speed of 1,400 revolutions per minute. The volume of the precipitate is then read on the graduated scale.

The reading in pure maple goods of average quality will vary from 1.5 to 3 c. c. High grade syrups that have been carefully filtered show a reading which is rarely less than 1.2 c. c., while dark colored and rank sugars containing large amounts of malate of lime may give a reading of over 5 c. c. Cane sugar naturally gives but a trace of precipitate. Maple goods adulterated with cane syrup or sugar show readings from 0.1 to 1 c. c. Commercial samples showing a reading of 1 c. c. may be regarded with suspicion; if much below that figure, they are surely adulterated. On the other hand, samples reading over 1 c. c. are not necessarily pure. The method has its limitations, but if these are thoroughly understood the process is of great value, particularly if doubtful cases are subjected to the more complete chemical analysis previously outlined.

The method just described was designed more especially as a factory test to enable buyers the better to judge as to the sophistication of the maple product by the original producer. It has been successfully used by two large buyers of maple goods and has enabled them to detect several cases of adulteration.

DISCUSSION OF RESULTS[3]

TABLE I. PURE MAPLE SYRUP

The syrups scheduled in Table I, with but few exceptions, were well clarified, either by the producer or by subsequent sedimen-

[1]See Vt. Sta. Rpt., 17, p. 454 (1904).

[2]A similar test has been more perfectly worked out by Julius Hortvet. Jour. Amer. Chem. Soc. 1904, 26 :1523; also U. S. Dept. Agr., Bu. Chem., Circ. 23 (1905).

[3] It should be understood that the writer makes no attempt to outline methods for sucrose, glucose and reducing sugar estimations. This subject has already received ample attention. For details applicable to maple goods the reader is referred to an article by Julius Hortvet, Jour. Amer. Chem. Soc. 26: 1538 (1904); also Canada Inland Revenue, Buls. 25 (1891), and 45 (1896), and Leach, Food Inspection and Analysis (1905).

tation in the laboratory. The total ash varies from 0.50 to 0.86 percent, and insoluble ash from 0.16 to 0.51 percent, the maximum figure in each case being due to number 122, which, while of unquestionable purity, was a very rank sample containing foreign inorganic impurities in suspension due to careless methods of manufacture. Soluble ash alkalinities vary from 0.30 to 0.66 c. c. of N-10 acid, and the insoluble from 0.36 to 0.94 c. c. The ratios in column F show extremes of 0.7 and 2.6, with an average of 1.7. The minimum alkalinity of one gram of soluble ash (column G) is 91 c. c. of N-10 acid, with a maximum of 172 c. c. The corresponding alkalinities of the insoluble ash are 184 c. c. and 300 c. c. Calculated as calcium carbonate these individual values for insoluble ash show over 100 percent in all but three (less than 7 percent) of the forty-eight samples examined. This is probably due to a partial conversion of carbonate into oxide in the incineration of the usually small amounts of insoluble ash. As a rule it may be said that the finer the quality of the pure goods and the less insoluble ash they contain the greater will be this increase in alkalinity value. Repeated but unsuccessful attempts have been made to guard against this conversion by treating the ash with ammonium carbonate solution and again heating at a very low temperature, both in platinum and porcelain dishes.

It will be noted that an average of 63 percent (column J) of the total ash is water soluble, the extremes being 41 and 74 percent. The lead subacetate precipitate figures reported in column K show a minimum of 0.9 c. c. (No. 116). No other sample gave a reading below 1 c. c. The average is 1.51 c. c.

The malic acid values displayed in the last column show a few marked variations. While occasional exceptions are to be noted, yet, in the main, the malic acid value varies in proportion to the insoluble ash present. The writer places the minimum malic acid value at 0.40. This test has been found a very satisfactory one, requiring but little working time and preferable for the general run of work to determinations of malic acid based on precipitation with lead acetate, removal of lead with hydrogen sulphide and the titration of filtrate.

TABLE II. PURE MAPLE SUGAR

It is well recognized that in most instances the removal of malate of lime or other sediment is much more thoroughly accomplished in syrup-making than in sugar-making for the reason that it is noticeable, and, therefore, objectionable in the former, while it is likely to pass unnoticed in the latter. This being true it follows that the ash content of maple sugar should show greater extremes and a higher

average than do maple syrups. The analyses of pure maple sugar in the table show that such differences exist. The total ash varies from 0.64 to 1.32 percent. The minimum figure was obtained with No. 33, a remarkably pure sample, the syrup from which it was made having been carefully purified. No. 36, which afforded the maximum figure, was a rank specimen of last run sugar. These two samples also are the source of the minimum and maximum data for the insoluble ash, the low figure of the former—0.20 percent—being due to the relative lack and the high figure—0.87 percent—to the abundance of crude malate of lime. The percent of ash, soluble in water, drops to 53, brought about by the increase in insoluble ash.

Knowing that the malic acid value in sugars could not consistently be lower than in syrups, individual tests were not made, but twenty-four sugar samples were composited into four as indicated by the brackets under K and L. Lead subacetate precipitate and malic acid value were determined in each composite. Tests for the latter were also made in Nos. 151 and 153.

In 13 out of 43 samples the estimated calcium carbonate content calculated from column H was less than 100 percent. This is equivalent to 30 percent (a decided gain over that noted in syrups, Table I), and indicates that with increased amounts of insoluble ash the danger of a partial conversion to oxide is lessened.[1]

TABLES III AND IV. ADULTERATED MAPLE SYRUP AND SUGAR

When refined cane sugar is added to maple goods the amount and alkalinity of the normal ash is diminished. In other words, cane sugar acts as a simple diluent. The variations in ash exhibited in the tables are necessarily due to the amount of the adulterant used and the character of the maple product adulterated.

The first five analyses reported in Table III serve clearly to show the effect on the ash content of the abundant use of cane sugar containing but traces of ash. The total ash is below 0.50 percent. This alone is sufficient to condemn the goods, although the insoluble ash in all cases runs below the minimum of 0.15 percent. The alkalinities, columns D and E, are also low, but when calculated to the 1 gram basis, columns G and H, show quite normal figures. This is again proof of the quality and character of the adulterant used.

The first twelve samples in Table IV show the effect of a similar adulteration of maple sugar. All of these samples, with the exception

[1]It may be remarked in this connection that this conversion to oxide seems to be a matter of common occurrence. Numerous analyses of maple products made in other laboratories where insoluble ash and its alkalinity have been reported, if calculated to the 1 gram basis, give as high results as those reported herewith.

of No. 75, although liberally adulterated with refined granulated sugar, were well calculated so far as appearance and flavor went to pass the usual tests of eye and taste; nor would analyses have shown abnormal percentages of sucrose and reducing sugars. As with the syrups (Table III) so with the sugars; total ash runs low in every case, insoluble ash low in seven out of twelve samples, and alkalinity low throughout. The very small soluble ash alkalinities of samples 82, 73, 74 and 75 (columns D and G) are indicative of sulphates in the added sugar.

When cane or beet sugars containing appreciable amounts of ash are used to adulterate maple goods, other factors than mere total ash must be considered. Samples No. 203, 204,[1] 205,[1] and 206 in Table III and 201 in Table IV illustrate this condition. The low insoluble ash, the high ratio shown in column F, together with the very high percentage of ash, soluble, (column J) are sufficient to reveal the nature of the sophistication. Should other data be desired determinations of sulphates, lime, potash and soda would be in order, together with lead subacetate precipitate and malic acid value. Sample No. 206 gave a malic acid value of 0.40. Additional analyses might be given, but those cited are sufficient to indicate the nature of the data which serves to reveal these forms of adulteration.

TABLE V. MISCELLANEOUS PURE MAPLE PRODUCTS

Stirred sugar is made from syrup boiled to about 250° F., poured into suitable vessels and stirred with paddles until a dry granular sugar is formed. Stirred sugar often resembles some of the grades of commercial brown sugar in appearance, although the taste reveals a flat and somewhat rank maple flavor. It may be roughly distinguished from brown sugar by dissolving a few ounces in water, boiling and noting the aroma. It usually shows a relatively high total ash content and contains 5 percent or less of water. Both samples gave a malic acid value of 1.10. Made into syrup and clarified by filtration the following results, on a syrup basis, page 328, were secured:

	No. 48	No. 49
Total ash	0.81%	0.78%
Soluble ash	0.50 "	0.46 "
Insoluble ash	0.31 "	0.32 "
Alkalinity soluble ash	0.76 c.c.	0.68 c.c.
Alkalinity insoluble ash	0.82 c.c.	0.79 c.c.

Drained sugar.—Much of the farm-made maple sugar is run into wooden tubs and sold to the wholesaler in this form. The syrup from which it is made is often not boiled to a high density, and as

[1]Results kindly furnished by Hortvet.

a result the sugar drains more or less on standing.[1] Thus the upper portion of the tub may be very light colored, firm and dry, while the lower portion is several shades darker and quite moist. The divergencies which may be expected in the ash content of the goods as a result of this condition of affairs are shown in samples No. 50 to 59. The low soluble ash is characteristic of the drained portion. Such samples will rarely be found in the retail trade, but are given to show the extremes often met with in the analysis of maple goods.

Maple cream.—Maple cream is a delicacy in considerable demand in fancy cookery. Large amounts are sold to the English trade. This product should not be confused with a cheaper article sold under the same name, made from the poorest maple syrup or sugar. The color and flavor enable one easily to distinguish between the two. The sample analyzed was obtained from a local manufacturing and jobbing house, the Welch Bros. Maple Co. of Burlington. It carried 77.94 percent of sucrose and 4.13 percent of reducing sugars. It is made from first quality maple syrup or sugar in such a manner that the grain is destroyed. Its color ranges from a dark grayish to light brown.

TABLE VII. CANADIAN SUGAR

The Canadian maple sugar samples reported have not been included in the averages. The writer has had occasion during the past two seasons to examine critically the better grades of Canadian syrup and sugar and to note their great similarity to the corresponding Vermont article as regards color, flavor and texture. The ash analyses also show concordance with those reported in Table II.

The duty on Canadian goods of four cents a pound for sugar and forty-four cents a gallon for syrup at once renders the profitable use of the latter in the United States extremely improbable. The sugar duty, however, is not prohibitory among the mixers. There exists a demand for a very hard sugar (one practically free from water), which is secured by boiling the syrup at high temperatures (300° F. has been reported, though it is probably nearer 270° F.) before sugaring off. This imported Canadian sugar is therefore of necessity hard, dark colored, rank in flavor and often burnt, but it stands transportation well, is not influenced by temperature changes, contains but little water and makes a most desirable base for the large additions of cane sugar by the sophisticator.

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[1]This is apt to occur unless the thermometer registers 240° F. or over, although it is to some extent a matter of the "run."

TABLE VII. BROWN SUGARS, ETC.

The brown sugars analyzed were common grades. No. 89 was too rank for use as an adulterant, since both color and flavor would condemn it. The others were fairly light in color, No. 90 being almost white. Had such sugars been used to adulterate maple goods the total ash in the mixture might have been within the limits, but the large proportion of soluble ash (columns B and J), the correspondingly low insoluble ash, not to speak of the abnormal sulphate content and the malic acid value, would have served to render detection an easy matter. None of the brown sugars afforded a malic acid value of over 0.19.

The raw cane sugar samples evidently contained insoluble inorganic material. When made into syrup and filtered, these suspended impurities were removed (see results No. 189, 187 and 185) and the ash materially lowered. Syrups boiling at 219° F. made from this grade of sugar are very hard to filter according to the method outlined on page 328. They gave an average malic acid value of 0.35 and the volume of the lead subacetate precipitate was 0.90 c. c.

When such grades of beet sugars as are represented by Nos. 190 and 191 are used for the adulteration of maple goods their presence may be detected in the manner indicated for brown sugar (consult results in columns B, F and J). The soda determination as indicated farther along in this article is also likely to give enlightening evidence. Other samples of beet sugar, however, were analyzed, but showed only a trace of ash. Their use as adulterants of maple goods would serve merely to lower the standard figures for pure goods, as is explained under cane sugar addition, page 324. The malic acid value of No. 190 was 0.08.

The insoluble ash of pure maple products consists largely of carbonate of lime derived from the incineration of calcium malate. It is readily soluble in tenth normal hydrochloric acid with a noticeable effervescence of carbon dioxide. A black or brown insoluble residue is rarely seen in this solution, save perhaps in very low grade syrups and sugars (see Table I, Nos. 119, 122, and Table II, Nos. 15, 16 and 36). Such a residuum is frequently observed, however, in sophisticated maple goods, and its presence should at least be noted, even if the amount is not determined, as presumptive evidence against the material under examination.

TABLES VIII AND IX. FILTRATION OF SYRUP AND SUGAR SAMPLES

The wide variations in ash content shown by different pure maple syrups and sugars, which appear to be due mainly to differences in the details of manufacture, have led the writer in the interests of

a more certain determination of the presence or absence of adulterants, to endeavor to narrow these divergencies by an arbitrary but simple process of clarification, conducted as follows:

About 40 grams of the syrup or sugar under examination are placed in a 4-oz. beaker. From 5 to 10 c. c. of hot water are added to syrup, while 15 to 20 c. c. are used to dissolve the sugar. The resulting syrup is carefully boiled over asbestos board, with occasional stirring, until an accurate and delicate thermometer indicates a boiling point of 219° F. for good or medium grade, or 220° F. for poorer grade goods.[1] The syrup is now filtered hot through dry double S. & S. 597 filters without suction. Pure goods usually filter quite rapidly, and as less than 20 grams are required for the estimation of ash, malic acid value and lead subacetate precipitate, but little delay is occasioned. This procedure is advantageous for several reasons:

1. It brings all samples on a common basis of concentration.

2. The filtration medium (double S. & S. 597 filters), with its attendant clarification, is unified.

3. Minima of variations in ash content, malic acid value and lead precipitate are secured.

4. It appears to be a necessity precedent to the detection of small additions of foreign sugar.

5. Incidentally, the aroma can be observed and the ease or rapidity of filtration—an indication of character—noted.

The data in Tables VIII and IX show the effect of this treatment on pure maple syrup and sugar. The similar numbers on the corresponding samples in Tables I and II enable one by cross reference readily to note the changes wrought by this simple procedure. While the changes which this treatment produces in the ash content of the syrup samples are not very marked, yet when sugars are in hand the effect is pronounced. This may be particularly noted in column C, showing the insoluble ash content.[2] The average reduction in total ash in syrups is 13 percent and in sugars 44 percent. The maximum figures are greatly lessened.[3]

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[1]See Vt. Sta. Rpt., 5, p. 160 (1891) for effect of altitude on boiling point. The Vermont station building is located about 350 feet above sea level.

[2]See also Table X, last two sections.

[3]The high figure on No. 122, Table VIII, was obtained with the abnormal syrup previously mentioned and can well be omitted from the averages. Samples No. 180, 181, 182 and 183 were made by compositing 24 samples of sugar as indicated by the brackets under columns K and L in Table II. Their malic acid values were respectively 0.41, 0.45, 0.46 and 0.40, and the corresponding lead precipitates were 1.40, 1.30, 1.65 and 1.60. These were the figures used in securing results indicated in columns K and L in the last section of Table X.

The writer has found no maple syrup or sugar of known purity affording lower total ash results by this method than 0.50 percent or lower insoluble ash than 0.15 percent, accompanied by the characteristic alkalinity. The test has been tried repeatedly with the finest quality goods obtainable. The following instance may be cited: A carefully made syrup, freed from malate of lime by straining through flannel, was stored for ten months in a sealed can. A sample was carefully siphoned. One portion was passed through double filters after warming sufficiently to admit of filtration, while another was diluted, boiled and filtered as outlined by the method above.

	Original syrup	Filtered syrup	Boiled and filtered syrup
Total ash	0.50%	0.50%	0.50%
Soluble ash	0.32 "	0.32 "	0.32 "
Insoluble ash	0.18 "	0.18 "	0.18 "
Alkalinity of soluble ash	0.44 c.c.	0.48 c.c.	0.46 c.c.
Alkalinity of insoluble ash	0.50 c.c.	0.50 c.c.	0.50 c.c.

Slight differences exist only in the alkalinity of the soluble ash. The exact triplication of the ash results was unexpected and, of course, is simply a coincidence. Variations of 0.01 or 0.02 percent are apt to occur.

Another instance is worthy of note. No. 155, Tables I and VIII, was a high grade syrup made in 1893. It remained in a sealed quart bottle twelve years, and was recently opened by the writer. A slight sediment was visible on the bottom of the bottle, but did not enter into the portion taken for analysis. The effect of boiling and filtering is shown in the tables mentioned. It would seem, therefore, that a certain minimum amount of ash cannot be removed from pure syrup, or sugar made into syrup, by the ordinary methods of filtration, and that even the slow and complete filtering which is effected by this method failed to remove sufficient ash from the pure goods to admit even a suspicion of adulteration.

The value of this method in detecting small additions of cane sugar is shown below:

1. Original pure maple sugar, rather poor grade.
2. Original pure maple sugar, dissolved, boiled and filtered.
3. Twenty percent cane sugar added to original sugar; dissolved, boiled and filtered.

	1	2	3
Total ash	1.08%	0.52%	0.43%
Soluble ash	0.44%	0.34%	0.29%
Insoluble ash	0.64%	0.18%	0.14%
Alkalinity soluble ash	0.60 c. c.	0.48 c. c.	0.43 c. c.
Alkalinity insoluble ash	0.58 c. c.	0.55 c. c.	0.42 c. c.

If an examination of an original sample shows that some one or all of the salient factors are below the minimum, the boiling and filtering method is, of course, unnecessary. But pure food analysts are often confronted with maple goods of doubtful purity. In such cases the procedure above outlined may frequently prove of service. It is suggested, moreover, that before passing or condemning such materials other samples of the same brand from different localities be secured and examined. The chances are that the mixer's formulas remain constant as to amounts of foreign syrup added, while his maple sugar stock is liable to vary greatly in ash content, malic acid value, etc.

TABLE X. SUMMARY

A summary of the results in Tables I, II, VII and IX is given in Table X. Dry matter bases of 65 percent for syrups and of 90 percent for sugars are assumed, an assumption which the writer's experience leads him to believe is very close to the average that would have been secured had a complete analysis of each sample been made.

STANDARDS

It is safe to say that pure maple goods will analyze within the extremes indicated in Tables I, II, VIII and IX and summarized on a dry matter basis in Table X. The minimum standards, which seem warranted when applied to a filtered syrup weighing 11 pounds to the gallon, are:

Total ash, not less than 0.50 percent.

Insoluble ash, not less than 0.15 percent.

Malic acid value, not less than 0.40 percent.

Lead subacetate precipitate, not less than 1.00 c. c.

LIME (CaO), POTASH (K_2O) AND SULPHATE (SO_3) RATIOS

"The complete analysis of the ash of pure maple goods shows it to consist largely of carbonates of lime and potassium, with relatively small amounts of magnesium, sodium and silica. Manganese is also a normal constituent."[1] Sulphates and phosphates are also present in small and varying quantities. The determination of the former is of use at times in detecting adulteration, since sulphates are present in relatively large amounts in many commercial brown, cane and beet sugars.

The amounts of lime and potash also afford data useful in judging the purity of suspected samples. Owing to the work involved these determinations are needful only in important cases when other tests do not furnish convincing data.

[1]Vt. Sta. Rpt., 17, p. 456 (1904).

Gravimetric determinations of lime, potash and sulphuric anhydride in the ash of maple goods of known purity give results as follows:

The samples contributing to the results in Table XI may be thus briefly described:

No. 1, Table I, No. 112, Medium quality, 1904.
No. 2, Table I, No. 93, Poor quality, 1904.
No. 3, Table I, No. 147, Excellent quality, 1905.
No. 4, Table I, No. 149, Good quality, 1905.
No. 5, Table I, Composite from Nos. 114, 115, 97, 116, 117, Excellent quality, 1904.
No. 6, Table I, Composite from Nos. 102, 103, 104, 105, 106, 94, 107, Excellent quality, 1904.
No. 7, Table II, Composite from Nos. 1, 2, 3, 4, 5, good grade, 1904.
No. 8, Table II, No. 36, Very dark last run tub sugar, 1903.
No. 9, Table II, No. 3, Good grade early run cake sugar, 1904.
No. 10, Table II, No. 12, Excellent quality last run sugar, 1904.
No. 11, Commercial brown sugar, light colored, purchased 1903.
No. 12, Commercial brown sugar, very dark, purchased 1904.
No. 13, Commercial brown sugar, very light colored, purchased 1904.

TABLE XI. 100 PARTS OF ASH CONTAIN

No.	Material	Percent CaO	Percent K_2O	Percent SO_3	Ratio of CaO to K_2O 100 :	Ratio of CaO to SO_3 100 :	Ratio of K_2O to SO_3 100 :
1	Maple syrup,	18.03	31.97	2.30	177	12.7	7.2
2	" "	20.00	30.00	1.91	150	9.6	6.4
3	" "	23.98	38.98	1.06	163	4.4	2.7
4	" "	19.81	35.90	0.68	181	3.4	1.9
5	" "	20.76	36.22	1.58	174	7.6	4.5
6	" "	21.86	35.48	1.74	162	8.9	4.9
7	Maple sugar,	23.16	25.69	2.42	110	10.4	9.4
8	" "	31.74	18.26	1.67	57	5.2	9.1
9	" "	23.01	29.04	1.51	126	6.6	5.2
10	" "	21.03	32.95	1.67	153	8.0	5.1
	Minimum,	18.03	18.26	0.68	57	3.4	1.9
	Maximum,	31.74	38.98	2.42	181	12.7	9.4
	Average,	22.34	31.45	1.65	141	7.4	5.3
11	Brown sugar, L	4.17	39.58	4.86	949	117	12
12	" " D	11.32	30.72	17.78	272	157	58
13	" " L	21.62	55.40	5.95	257	27	18
14[1]	" "	15.63	40.62	4.58	260	29	11
15[2]	Adulterated maple syrup,	2.35	32.52	4.56	1384	194	14

[1]Hortvet, Jour. Am. Chem. Soc. 26:1541 (1904).
[2]Calculated from results given by Hortvet.

Care was taken in the selection of the samples for this purpose to secure extremes. Thus, syrups 3, 5 and 6 were of the finest grade, while No. 8 on the other hand was as rank a specimen of pure maple

sugar as the writer has ever seen. No attempt had been made during its manufacture either to remove malate of lime or to prevent burning. No. 12 (brown sugar) was of such a character as to inhibit its use as an adulterant.

The highest lime content was found, as might be expected, in the inferior quality sugar No. 8. This sample also carried the minimum potash content. The high grade, carefully prepared syrup samples, Nos. 3, 4, 5 and 6, contained the largest percentages of potash. The variations in sulphates from 0.68 to 2.42 percent were quite marked, but no direct relationship between the character of the samples and their sulphate content can yet be traced. Soil, seasonal or, perhaps, local conditions not understood may be the cause. The amounts present in the brown sugars thus far examined are far in excess of those observed in pure maple goods. It should be remembered, however, that the low sulphate content of an otherwise suspicious sample should not be taken as necessarily indicative of purity. A high figure is positive proof; a low one may or may not be suggestive.

The three columns in Table XI giving ratios, are particularly suggestive and clearly serve to illustrate the differences existing between pure maple goods and brown sugars containing appreciable amounts of ash. It is probably true that refined sugars show similar variation due to the greater proportions of potash and soda normally present. The amount of soda present in the ash of maple products does not exceed 8 percent thereof, and the average is under 5 percent. Occasion might arise in dealing with adulterated maple samples where this estimation would be advisable, in that the relationship between a normal potash percentage and soluble ash alkalinity might be caused by the presence of considerable amounts of soda and sulphates derived from the added cane or beet sugar.

The writer ventures the opinion that the sophistication of maple goods now on the market can be detected in the majority of cases by the methods previously indicated without resort to gravimetric determinations of lime, potash and sulphuric acid. It should be noted, however, that where the latter are necessary an approximation to similarity in the case of any one of the average ratios indicated in Table XI ought not to be considered conclusive one way or the other; but if a fair agreement in all three cases is secured the evidence has the added strength of the traditional threefold cord.

COMPARISONS BETWEEN ASH AND MALIC ACID VALUE

The relation which exists between the ash contents of pure maple sugars and syrups and their malic acid values appears to be a fairly constant one and worthy of attention. The writer has endeavored

to indicate this in tabular form. The letter headings, A, B, C and L, are explained in the outline adopted for ash analysis, page 316. To show the variations between samples it was thought best to use the sugar samples 180, 181, 182 and 183, as they represent twenty-four different samples of known purity. (See Table II, and the corresponding syrups made from them analyzed in Table IX). The average of all the syrups in Table I, and the sugars in Table II are then given. These are followed by results on brown sugars, etc., and an adulterated maple syrup, which serve to show the points of difference desired.

TABLE XII. COMPARISON BETWEEN TOTAL, SOLUBLE AND INSOLUBLE ASH, AND MALIC ACID VALUE

	Ash analyses				Malic acid value (L) equals percent of		
Maple sugar	A	B	C	L	A	B	C
No. 180,	0.77	0.43	0.34	0.78	101	181	229
181,	0.94	0.50	0.44	0.84	89	168	191
182,	1.01	0.45	0.56	0.75	74	166	134
183,	0.90	0.47	0.43	0.65	72	138	151
Average,	0.90	0.46	0.44	0.755	84	164	172
ABOVE SUGARS, DISSOLVED, BOILED AND FILTERED, AS DESCRIBED UNDER DISCUSSION OF RESULTS, TABLES VIII AND IX							
No. 180,	0.50	0.33	0.17	0.41	82	124	241
181,	0.53	0.37	0.16	0.45	85	121	281
182,	0.53	0.27	0.26	0.46	87	170	177
183,	0.52	0.37	0.15	0.40	76	108	267
Average,	0.52	0.34	0.18	0.43	83	126	238
SYRUPS. TABLE I							
Average,	0.60	0.38	0.22	0.53	88	140	241
SUGARS. TABLE II							
Average,	0.91	0.48	0.43	0.75	82	156	174
BROWN SUGAR, RAW CANE SUGAR, BEET SUGAR. TABLE VII							
No. 90,	1.44	1.30	0.14	0.16	11	12	114
189.	0.26	0.16	0.10	0.35	135	219	350
190,	0.86	0.78	0.08	0.08	9	10	100
ADULTERATED MAPLE SYRUP. TABLE III							
No. 206,	0.54	0.48	0.06	0.40	74	83	67

This table is particularly applicable to cases where a low malic acid value accompanies a fairly normal total ash, or where a high malic acid value is present with a low or normal total ash. For obvious reasons it is not of value (nor is it needed) where refined cane sugar is the sole adulterant.

INTERPRETATION OF RESULTS

So many considerations enter into the detection of adulteration in maple products that the analyst should at the outset become familiar with the exact nature and behavior of the known pure article. The large additions of cane and brown sugar so generally used to-day can now be easily detected by determining the ash, malic acid value and lead precipitate But the analyst will be obliged in the near future to wrestle with more doubtful cases. The several determinations which will be necessitated and physical characteristics to be noted in such cases are the following: Sucrose, reducing sugars, glucose, moisture, total, soluble and insoluble ash and alkalinity of the same, malic acid value, lead precipitate, sulphates, lime, potassium, sodium, manganese, appearance of ash, and color, flavor, aroma and specific gravity of the syrup.

The reader will notice that standards for both inorganic and organic constituents have been suggested and that, therefore, the possible agreement with *one* of these does not by any means prove the purity of the sample. A reasonable conformity to standards in *all* the lines indicated should be required.

DETECTION OF ADULTERATION IN MAPLE PRODUCTS

Analytical scheme.—A, percent total ash; B, percent soluble ash: C, percent insoluble ash; D, alkalinity of soluble ash,[1] c. c. n-10 HCl for ash of 1 gram of sample; E, alkalinity of insoluble ash,[1] c. c. n-10 HCl for ash of 1 gram of sample; F, ratio insoluble to soluble ash, B÷C; G, alkalinity of 1 gram soluble ash, (D×100)÷B; H, alkalinity of 1 gram insoluble ash, (E×100)÷C; I, ratio H to G, G÷H; J, percent ash, soluble, (B×100)÷A; K, lead precipitate; L, malic acid value; M, sulphuric acid.

Preparation of sample.—Get 40 grams of sample into form of syrup boiling at 219° F., and filter, hot, through double S. & S. 597 filters without suction. Test filtrate as outlined above.

Minimum standards for pure maple syrup.—Total ash, A, 0.50 percent; insoluble ash, C, 0.15 percent; malic acid value, L, 0.40 percent; lead precipitate, K, 1.00 c. c.

ADDITION OF CANE OR BEET SUGAR CONTAINING TRACES OF ASH. INDICATED BY*

A	B	C	D	E	F	G	H	I	J	K	L	M
—	—	—	—	—	N	N—†	N+	N	N	—	—	N+

*—Low, +High, N Normal, N— Normal to low, etc.
†If —, SO_2 is indicated.
[1]Methyl orange to be used as indicator.

ADDITION OF BROWN SUGAR OR BEET SUGAR CONTAINING 0.50 TO 1.00 PERCENT OF ASH, INDICATED BY*

A	B	C	D	E	F	G	H	I	J	K	L	M
N+	+	—	—N	—	+	†—N	N	—N+	+	—N	—	+

GENERAL COMMENTS

Aroma.—"The odor of maple products is at once pleasing and characteristic. That it is due to some partially volatile principle, the odor of boiling sap or syrup makes plain. This aroma is at its best when the goods are fresh. It is so apt to be 'bound up' in old and dry samples as to be apparently lacking. The writer has found it helpful when dealing with samples of this character, or with commercial products of unknown origin, to 'bring out,' so to speak, the true maple odor, if present, by the following procedure: About 20 grams of sugar or syrup weighed into a 4-ounce beaker, dissolved in from 20 to 40 c. c. of hot water, are placed on an asbestos board and boiled. The amount of water added varies with the sample, but as carried out here if the syrup boils at 215° F. or under the desired consistency has been obtained. After a few minutes' gentle boiling, with occasional stirring, the odor is noted, either while still boiling or *immediately* after removal from the heat. Parties familiar with the true maple aroma—chemists and non-chemists alike—have been thus able to distinguish the pure from the adulterated goods, though possessing no previous knowledge of the samples on which they were called to pass. No claim is made that this test in itself should serve either to condemn or to pass goods, but the result considered in connection with other analytical data possesses value."[1] The writer has yet to see a pure maple syrup that, even after souring or long keeping under any reasonable conditions, will not furnish an abundant maple aroma on boiling after dilution with water.

Flavor.—The flavor or taste of maple goods may serve in a measure to indicate their purity. Inasmuch as many pure maple syrups, particularly those produced in certain sections of the country, have what might be termed a "molasses taste," it is best not to form hasty opinions from this sense alone, especially if the origin, age and conditions of manufacture are not known. The flavor taken into consideration with color is a good criterion as to *quality* of maple products.

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*See * and † footnotes opposite.
[1]Vt. Sta. Rpt., 17, p. 455 (1904).

Color.—"The color of maple syrup and sugar is no indication of purity. Pure goods may be almost snow white, or they may be nearly jet black or any intermediate shade of brown. The color of pure goods is largely dependent on the methods used in handling and boiling the sap. The careless operator, even with the best utensils, will produce a poor grade, highly colored syrup or sugar. On the other hand, his cleanly and careful neighbor will make a first grade material. The reasons for this condition are well understood and explanations are unnecessary."[1] As a rule first quality sugar brings a cent or two a pound at wholesale more than the second grade, while with syrups the price may range five or ten cents more a gallon. There is, however, at present a ready market for pure goods, regardless of color; so it remains with the individual producer to decide what quality he will make.

Characteristics of maple syrups from different sections.—The general characteristics of maple syrups from different sections of the sugar producing areas that have come under the writer's notice may be thus briefly described. Remarks refer to average quality goods:

Pennsylvania: Sweet and flat (often like molasses); maple flavor.
Ohio: Mild, delicate almost to flatness; maple flavor.
New York: Strong; maple flavor.
Vermont: Mild, delicate; good maple flavor.
Canada: Good maple flavor. Bulk of product dark in color, with strong flavor, occasioned by demand.

As far as marketable differences go, there is but small choice between Vermont, New York and Canadian goods of equal grade.

Appearance of ash.—"The appearance of the ash of pure maple goods is apt to be characteristic. The writer has repeatedly observed that white (refined) and brown sugar require much longer heating for complete incineration than do maple goods; that in many cases it is very hard to get rid of the last traces of carbon; and that the resulting ash is often of a granular character. Pure maple products, on the other hand, burn much more readily to a white or gray ash, which is usually of a leafy, net-work structure. Again the water-soluble ash solution of the latter may exhibit, even after filtration, a pronounced cloudiness not cleared by the addition of hydrochloric acid. This has never been noticed when analyzing brown sugar or maple goods heavily adulterated with white sugar."[2] When 5 grams are used for the analysis, the writer rarely finds it necessary, with pure goods, to rid the ash of remaining particles of carbon, by cool-

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[1] Vt. Sta. Rpt., 17, p. 456 (1904).

[2] Vt. Sta. Rpt. 17, p. 447 (1904).

ing, moistening with water and reheating. When this is essential the ash net-work above mentioned is destroyed and a residue similar to that described by Hortvet[1] is obtained. This is the case in the writer's laboratory when 10 grams of material are used for the determination. Comparisons on pure goods, with or without the water treatment, gave practically similar results when working with 5 grams of substance.

Sulphates greater in syrups than sugars.—It has been observed[2] that the percentage of sulphates appears to be greater in maple syrup than in maple sugar, although no explanation has been offered. In the writer's opinion it may be accounted for as follows: The percentage of ash, soluble in water, is greater in syrups than in sugars. Thus the average seen in column J in Tables I and II shows 63 percent soluble in syrups, and 53 percent in sugars. It amounts to a difference of 10 percent or an increase of 18 percent. This is due entirely to the larger quantity of malate of lime (insoluble ash) in the sugar. As sulphates are found largely in the soluble ash they would therefore average greater on an ash basis in syrups than in sugars. It would be an easy matter to select samples to show this difference, even on an original material basis.

It should be borne in mind that the pure sap syrup of the farm, which has never been made into sugar, is clarified more perfectly when sold as such than would be the case if it were made into and sold as sugar. Once made into sugar, if again converted into syrup, a certain percentage of insoluble ash is removed by the filtration process employed by the manufacturer.[3]

In support of the opinion offered, take the sugar samples Nos. 50 and 51, Table V. The ash analysis is there given, and it should be noted that the percents of ash, soluble, column J, are respectively 16 and 50. Sample No. 50 was a drained sugar, hard and dry and very light colored, taken from the upper portion of fifty-pound tub. No. 51, taken from the same tub, was the lower portion, dark colored and soft. SO_3 determinations are as follows:

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[1]Jour. Am. Chem. Soc. 26:1541 (1904).

[2]Hortvet, Jour. Am. Chem. Soc. 26:1542 (1904).

[3]The bulk of the pure (in fact as well as in name) maple syrup put on the market by supply houses is made by dissolving, boiling and filtering maple sugar. Hence commercial samples of pure maple syrup are apt to show ash contents more nearly approximating the minimum figures (see Tables I, VIII and IX) than will equally pure (i. e. genuine) samples made on the farm, because of the more thorough removal of the impurities by the manufacturer."—Vt. Sta. Rpt., 17, p. 454 (1904).

SO_3 IN ASH OF MAPLE SUGAR

	Original material	100 parts of ash contain
No. 50,	0.0077%	0.54%
No. 51,	0.0117 "	1.05 "

Density.—Standard maple syrup should weigh eleven pounds to the gallon. It should boil[1] at a temperature of 218 to 219° F. and at ordinary temperature give a reading with the Baumé hydrometer of 35.5 to 36 degrees, corresponding to a specific gravity of about 1.325. A syrup giving a Baumé reading of 31 degrees at the boiling point will when cool generally show the standard reading of 36 degrees.

Maple syrup in bulk is usually purchased on a basis of an agreed price per standard gallon. This price, depending as it does on supply, demand and quality, has varied in the past few years from 60 to 80 cents a gallon. As a large percentage of the syrup as originally made weighs less than the eleven pound standard, proportionately less per gallon should be paid for the lighter syrup.

The following table has been prepared to be used in calculating payments: To facilitate the operation the prices covering Baumé readings from 30 to 36° for standard syrup at 70, 65 and 60 cents a gallon have been calculated.

	Baume	Factor	Price per gallon in cents		
Standard 11 pound syrup..........	36	1.000	70	65	60
	35	.972	68	63	58.5
	34	.944	66	61.5	56.5
	33	.917	64	59.5	55
	32	.889	62	58	53.5
	31	.861	60	56	51.5
	30	.833	58	54	50

Example.—If 65 cents a gallon is to be paid for 11 pound syrup testing 36° Baumé, how much should be paid for 880 pounds of syrup testing 32° Baumé?

Divide the weight of the syrup by 11 to get the number of standard gallons. Multiply the price paid for 11 pound syrup by the factor opposite the Baumé reading of the syrup in question. This gives the price to be paid per standard gallon. The number of standard gallons multiplied by the price per gallon equals the amount to be paid.

Thus: $880 \div 11 = 80$ standard gallons.

65 cents $\times .889 = 58$ cents.

80×58 cents $= \$46.40$, price to be paid.

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[1]See Vt. Sta. Rpt., 5, p. 160 (1891) for effect of altitude on boiling point. The Vermont station building is located about 350 feet above sea level.

In conclusion, the writer wishes to express his thanks to Mr. Julius Hortvet, chemist of the Minnesota Dairy and Food Department, St. Paul, for results contributed and suggestions offered. Also to Mr. L. W. Welch, manager of the Welch Bros. Maple Co., of Burlington, Vt., for the many courtesies extended in the prosecution of this work, and particularly to Mr. H. H. Miller of the same company for general information given.

MISCELLANEOUS ANALYSES

C. H. JONES AND F. M. HOLLISTER

Section 263 of the Vermont Statutes requires the Station to analyze free of charge miscellaneous materials of an agricultural nature for residents of the State. Those deemed of sufficient interest to place on permanent record are here recorded:

MATERIALS FURNISHING NITROGEN

Material	From	Percent nitrogen
Nitrate of soda,	Burlington,	15.58
Nitrate of soda,	Jonesville,	15.79
Nitrate of soda,	Perkinsville,	15.61
Dried blood,	W. Brattleboro,	9.24
Concentrated tankage,	St. Albans,	12.71

MATERIALS FURNISHING NITROGEN AND PHOSPHORIC ACID

Material	From	Percent of nitrogen	Percent of phosphoric acid
Tankage,	St. Albans,	4.74	14.90
Ground bone,	St. Albans,	3.61	22.94
Ground bone,	Springfield,	2.60	26.76
Ground bone,	Burlington,	3.54	22.30
Bone meal,	Sutton,	3.44	21.00
Bone meal,	Sutton,	2.70	20.32
Bone flour (Raw knuckle),	Brattleboro,	3.79	24.64

MATERIALS FURNISHING AVAILABLE PHOSPHORIC ACID

		PHOSPHORIC ACID				
Material	From	Soluble percent	Reverted percent	Insoluble percent	Total percent	Available percent
Acid phosphate,	Burlington,	13.56	3.94	0.60	18.10	17.50
Acid phosphate,	W. Brattleboro,	7.96	7.11	2.17	17.24	15.07
Acid phosphate,	Jonesville,	8.60	5.74	1.20	15.54	14.34

MATERIALS FURNISHING POTASH

Material	From	Percent of potash
Muriate of potash,	Burlington,	52.90
Muriate of potash,	W. Brattleboro,	52.55

WOOD ASHES

No.	From	Soluble potash percent	Insoluble potash percent	Total potash percent	Total phosphoric acid percent	Calcium oxide percent	Insol. matter percent
1	L. Barry, Springfield,	4.24	2.17	6.41	1.16	31.30	9.70
2	Le G.B.Cannon,Burlington,	1.78	0.47	2.25	0.85	24.05	10.79
3	F. A. Kennedy, Windsor,	3.90	0.68	4.58	1.34	26.20	12.89

The Springfield sample was said to be a lime kiln ash. It carried more soluble potash than do the majority of samples of this nature. The Burlington sample, purchased for Canadian ashes, were evidently leached ashes. They carried 32.20 percent of water. The material from Windsor was of rather poor grade, and contained 22.33 percent water.

FERTILIZERS AND HOME MIXTURES

From	Nitrogen percent	Soluble Phosphoric acid percent	Reverted Phosphoric acid percent	Insol. Phosphoric acid percent	Total Phosphoric acid percent	Available Phosphoric acid percent	Potash percent
Geo. H. Brown, So. Strafford,	1.37	.....	....	4.85	10.40	5.55	1.32
Burl Rendering Co., Burlington,	2.46	trace	4.69	3.90	8.59	4.69	5.14

MUCK

	IN ORIGINAL SUBSTANCE				IN DRY MATTER		
From	Water percent	Ash percent	Organic and volatile matter percent	Nitrogen percent	Ash percent	Organic and volatile matter percent	Nitrogen percent
E.B.Parker,Boston,	56.45	35.48	8.07	0.21	81.47	18.53	0.49
" "	55.26	35.97	8.77	0.24	80.40	19.60	0.53
" "	58.15	34.41	7.44	0.24	82.22	17.78	0.58
H.F.Emery,Thetf'd,	32.25	5.17	62.58	1.89	7.64	92.36	2.79

The first three samples were pond sediment and, owing to the large amount of mineral matter present, could hardly be classed as muck. The last sample was a peat of good quality. If the bog is of sufficient area and easily drained, the material readily excavated and hauled, it could be used with economy, either as a fuel or fertilizer.

THE INFLUENCE OF CHANGES IN FEEDING UPON MILK PRODUCTION[1]

JOSEPH L. HILLS

Feeding trials with cows have been a prominent feature at this Station since 1888. During the last decade the general plan of their conduct has been a fairly consistent one. From forty to sixty cows yearly have been kept under careful observation during the five to seven months of their fall, winter and spring barn life, under conditions which have permitted the reasonably accurate measurement of the values of a great variety of rations, of feeding stuffs and of feeding practices. The immediate results of the sundry trials have been detailed in the several annual reports. The large volume of data which has accumulated lends itself readily to collation and to further calculation as to the effect upon production, not of this, that, or the other ration or feed, but of total and digestible nutrients, of digestible protein, carbohydrates and of calories of energy.

The limitations of the work are appreciated by none, perhaps, more fully than by the writer, who has had it more particularly in hand. Some of these, which no doubt narrow the applicability of the deductions, are that the animals used have been largely of one sort—grade Jerseys; that the meteorological conditions have been those of a somewhat rigorous winter climate; and that the cows have been under a single management, in one barn, and, save as regards changes in rations, uniformly handled. The quality of the hay which was fed at different times during the same trial was necessarily uneven, which has always proved a serious flaw in the conduct of the trials. Yet when all is said, the volume of the work when thus collated is such as to lend some weight to the conclusions which have been deduced from its study.

The data used are calculated from those published in the appendices of the tenth to the sixteenth reports inclusive. They comprise the records of 347 cows (not this number of individuals, however, as the same cows were often used season after season) fed from three to seven months in feeding periods of from four to six weeks duration.

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[1]This article had its genesis in a thesis presented at graduation by Mr. D. M. Walsh of the class of 1904. Mr. Walsh had general charge of the collation and calculation of the data, did much painstaking work thereon under the direction of the writer, and made several interesting generalizations.

Several of the records[1] for one reason and another are unsuited to the purpose; hence of the 1,500 or more only 1,292 were used. But when one contemplates the fact that a single "record" consisted of twenty-two different items of two to four figures each, each of which for the purposes of this article had to be handled five separate times, and that then the entire work was checked; and when one further learns that each one of nearly half of these "items" is the ultimate product of from thirty to forty-five individual records, the volume of the data which are concentrated in the tables in this article inspires some little respect. That in so great a mass of figures, so often handled and permuted, no errors should occur is too much to expect; but that material errors exist is doubted. Great care, repeated scrutiny and the application of many "cross checks" have served, it is thought, to eliminate all but minor errors, which on the doctrine of averages will usually balance each other.

The generalities concerning the sundry trials, as well as the details as to the animals used, their care, feeding, etc., will be found in the several reports. It may be said in brief that records of the weights of the food eaten and of the milk yielded by each cow were kept continuously; that constant analytical check was maintained of both food and milk; and that in no case is there a single record contributory in any way to any piece of data used in this article which was made during the first ten days when an animal was on a given ration; or, in other words, ten to fifteen days were always used in accustoming the cow to her new rations before account was taken of the results. The outcome should, therefore, indicate permanent rather than immediate effects, lasting rather than temporary results. Moreover all cases of abnormal feeding, of sickness, or of production of an average of less than ten pounds of milk daily, were excluded. In short, every effort was made to reject all records which seemed in the least open to doubt. The volume of the data is such that it is safe to say that in most of the computations the assumed average cow was from six and one-half to seven years old and four and a half to five months in lactation.

The experimental scheme involved the comparison of one ration with another which was fed during the four to six weeks succeeding the close of the use of the first one. During this time, of course, the normal shrinkage in milk flow due to advancing lactation occurred. In order to offset this shrinkage and to place the records of contiguous

[1]A "record" means such an accumulation of data as constitutes the second horizontal line of Table V appending this report, comprising 13 separate pieces of data.

periods upon an equal basis, the average data of production and those calculated therefrom were multiplied by the factors 0.96 and 1.042 respectively, in each table where large numbers of comparisons were at hand. These factors are equivalent to a 4.2 percent shrinkage[1] for the four or five week period lengths. In those cases where the number of comparisons were relatively few recourse was had to the original data as to average lactation periods and appropriate factors used.

The amounts eaten were as a rule sufficient to meet bodily needs. In some cases either scanty or superabundant rations were intentionally used. Gains in live weight, however, were the rule in three out of four cases, while losses were not more frequent than once in fifteen or twenty times, except where scant rations were fed. The average weights of the cow ranged from 800 to 900 pounds, few weighing as much as 1,000 pounds. In order, however, to make the results more certainly applicable and comparable—for generally the small cows ate less than did their larger mates—all the records of the daily feeding and production were calculated to the basis of the 1,000 pound cow. If the work of collation and calculation were to be entered upon anew with present information and experience as a guide, it is doubtful if this procedure would be followed. It is now thought that it did no harm; it is also thought that it was unessential.

It hardly need be said that it would be useless to print the mass of individual data and that it would consume much space. The condensed tables which occupy solidly the 16 pages, 346 to 361, may prove somewhat more clear if the following explanations are heeded. Taking the first one on page 346 as an illustration. A survey of the data (after calculation to the 1,000 pound cow basis) betrayed nineteen cases where in successive feeding periods the cow had been fed an unchanged ration and had eaten so exactly the same amounts of total and digestible nutrients of the several sorts that the two records were identical. The records of the first of the two periods in these nineteen cases were added and then divided by 19, as was done also with those of the second of the two periods. The calculated average yields of the milk, total solids and fat shown in the first of these two averages were then multiplied by the shrinkage factor, usually 0.96. Then the calculated average cost of food and, also, the weights of total and digestible dry matter and of the several nutrients as well as the calories of energy per pound of product as shown in the first of these two averages were multiplied by the converse of this factor, usually 1.042. These procedures enabled one to make approximately the proper allowance for the normal shrinkage characteristic of the aver-

[1]See Wheeler, N. Y. (Geneva) Sta. Rpt., 20, p. 71 (1901).

age state of lactation. The first of these records form the line A, the second line B in Table I. Tables II-XXIX were similarly calculated.

The tables show: (a) Food consumption; (b) Production and its cost; (c) Production proportioned to consumption.

The data under I, "Food consumption" (first seven columns), show the amounts of the sundry nutrients, (i. e. the pounds and fractions thereof of total dry matter, of digestible dry matter,[1] of digestible protein, of digestible carbohydrates [including digestible ether extract, multiplied by 2.25]); the nutritive ratio; and the calories of energy calculated from the average figures for digestible protein and carbohydrates by the use of the conventional factor (1840). It should be noted that the first five pieces of data are obtained by addition of the sundry columns and division by the number of items. Hence, the nutritive ratios are not an exact expression of the relationships of the protein and carbohydrate data as shown in the table, though they are always close approximations. The calories, however, not being a part of the original data, are direct calculations from the averages.

The data under II, "Production and Cost of Production" (columns 8 to 15 inclusive), show the average production of milk, total solids and fat, the composition of the milk, and the average cost of food eaten per pound of milk, of total solids, or of fat, all obtained as above explained, by addition and division. The percentages therefor are approximate rather than exact indications of the relations of the weights of milk, solids and fat. The costs are calculated from the estimated prices of roughages and actual prices of grain feeds, as yearly outlined in the discussions of the several feeding trials.

The data under III, "Production Proportioned to Consumption," (the entire matter on every right hand page) give the weight in pounds and fractions thereof of total and of digestible dry matter, of digestible protein and of digestible carbohydrates consumed in making a pound of milk, a pound of total solids and a pound of fat. They further show the calories of energy used for the same purposes. The first three sets of results—nine columns—are derived, as were those already discussed under I and II, by addition and division. The last two sets—six columns—were calculated directly, using data in columns 4, 7, 10, and 11 and 6, 7, 10 and 11 for the purpose. Hence, while the latter check with the published data, the former do not; yet both are correct. It would have been better to have had all the data of one sort or the other, but the volume of the calculations proved to be so great that they were not carried out in detail for the carbohydrates and the calories. The tables show data:

[1]American coefficients used; Jordan & Hall, U. S. Dept. Agr., Of. Exp. Sta. Bul. 77 (1900).

(a) When rations were unchanged;
(b) Ditto; more than 15.5 pounds of digestible dry matter;
(c) Ditto; less than 15.5 pounds of digestible dry matter;
(d) Ditto; varying from those carrying more to those carrying less than 15.5 pounds of digestible dry matter;
(e) When rations were changed;
(f) Ditto; more than 15.5 pounds of digestible dry matter;
(g) Ditto; less than 15.5 pounds of digestible dry matter;
(h) Ditto; varying from those carrying more to those carrying less than 15.5 pounds of digestible dry matter.

These tables, twenty-nine in number, appear on the next sixteen pages. Their nature is defined as closely as practicable in a few words below as well as by the captions of the separate tables.

TABULAR STATEMENT SHOWING THE GENERAL CHARACTER OF THE TABLES ON PAGES 346-361

Table number	Ration changed?	More or less than 15.5 lbs. of digestible dry matter fed	Total dry matter changed? Digestible dry matter changed?	Digestible protein changed?	Digestible carbohydrates changed? Calories changed?	Nutritive ratio changed?	Number of comparisons
I	no	....	no	no	no	no	19
II	no	more	"	"	"	"	68
III	no	less	"	"	"	"	15
IV	yes	more	"	"	"	"	85
V	yes	less	"	decreased	"	widened	10
VI	no	....	increased	no	increased	"	13
VII	yes	....	"	"	"	"	6
VIII	no	....	decreased	"	decreased	narrowed	121
IX	yes	....	"	"	"	"	13
X	no	....	no	increased	no	"	20
XI	yes	....	"	"	"	"	20
XII	no	....	"	decreased	"	widened	11
XIII	yes	....	"	"	"	"	8
XIV	no	....	increased	increased	increased	narrowed	45
XV	yes	....	"	"	"	"	143
XVI	yes	less	"	"	"	"	18
XVII	yes	from less to more	"	"	"	"	88
XVIII	no	more	"	"	"	"	52
XIX	yes	"	"	"	"	"	173
XX	no	....	decreased	decreased	decreased	no	70
XXI	yes	....	"	"	"	widened	217
XXII	yes	less	"	"	"	no	22
XXIII	no	from more to less	"	"	"	"	9
XXIV	yes	"	"	"	"	widened	50
XXV	no	more	"	"	"	no	89
XXVI	yes	more	"	"	"	widened	255
XXVII	yes	....	increased	"	increased	"	29
XXVIII	no	....	decreased	increased	decreased	narrowed	8
XXIX	yes	....	"	"	"	"	63

	Food consumption						Production					Cost of food to make 1 lb. of		
	Total dry matter	Digestible dry matter	Digestible protein	Digestible carbohydrates	Nutritive ratio	Calories	Milk	Total solids	Fat	Total solids	Fat	Milk	Total solids	Fat
	lbs	lbs	lbs	lbs	1:		lbs	%	%	lbs	lbs	cts	cts	cts

I. No change in rations; amounts of total and digestible dry matter, of all nutrients, and of calories unchanged; nutritive ratio unaltered. (19 comparisons.)

A	25.9	17.4	2.38	15.1	6.7	32510	19.8	15.05	5.39	2.94	1.04	0.69	4.6	12.9
B	25.7	17.3	2.38	14.9	6.6	32140	20.1	15.05	5.39	2.99	1.06	0.68	4.5	12.7
B ± A	−0.2	−0.1	0	−0.2	−0.1	−370	+0.3	0	0	+0.05	+0.02	−0.01	−0.1	−0.2
Perc'ts	−1	−1	0	−1	−1	−1	+2	0	0	+2	+2	−1	−2	−2

II. Ditto; digestible dry matter in excess of 15.5 pounds. (68 comparisons.)

A	27.3	18.1	2.70	15.6	6.0	34040	21.9	14.86	5.25	3.24	1.13	0.83	5.6	16.1
B	27.1	18.1	2.73	15.6	5.9	34090	21.8	14.91	5.31	3.21	1.13	0.85	5.7	16.2
B ± A	−0.2	0	+0.03	0	−0.1	+50	−0.1	+0.05	+0.06	−0.03	0	+0.02	+0.1	+0.1
Perc'ts	−1	0	+1	0	−2	0	0	0	+1	−1	0	+2	+2	+1

III. Ditto; digestible dry matter less than 15.5 pounds. (15 comparisons.)

A	21.6	14.2	1.91	12.2	6.7	26245	16.4	14.41	5.08	2.36	0.82	0.81	5.6	16.3
B	21.3	14.1	1.86	12.1	6.8	25970	16.4	14.32	5.00	2.33	0.81	0.81	5.7	16.3
B ± A	−0.3	−0.1	−0.05	−0.1	+0.1	−275	0	−0.09	−0.08	−0.03	−0.01	0	+0.1	0
Perc'ts	−1	−1	−3	−1	+1	−1	0	−1	−1	−1	−1	0	+1	0

IV. Rations changed; amounts of total and digestible dry matter, of all nutrients, and of calories unchanged; nutritive ratio unaltered; digestible dry matter in excess of 15.5 pounds. (85 comparisons.)

A	27.1	18.2	2.55	15.8	6.5	34130	22.0	14.62	5.08	3.14	1.08	0.81	5.6	16.0
B	26.9	18.2	2.62	15.8	6.4	34260	21.9	14.62	5.09	3.14	1.10	0.82	5.6	16.2
B ± A	−0.2	0	+0.07	0	−0.1	+130	−0.1	0	+0.01	0	+0.02	+0.01	0	+0.2
Perc'ts	−1	0	+3	0	−2	0	0	0	0	0	+1	+1	0	+1

	Total dry matter to make 1 lb. of			Digestible dry matter to make 1 lb. of			Digestible protein to make 1 lb. of			Digestible carbohydrates to make 1 lb. of			Calories to make 1 lb. of		
	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat
	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	cal	cal	cal
I. Rations same; total dry matter, 0; digestible dry matter, 0; digestible protein, 0; digestible carbohydrates, 0; calories, 0; nutritive ratio, 0. (19 comparisons.)															
A	1.40	9.4	26.0	0.95	6.2	17.4	0.13	0.85	2.38	0.76	5.1	14.5	1640	11060	31250
B	1.40	9.2	25.4	0.94	6.1	17.0	0.13	0.85	2.42	0.74	4.9	14.1	1590	10750	30320
B±A	0	−0.2	−0.6	−0.01	−0.1	−0.4	0	0	+0.04	−0.02	−0.2	−0.4	−50	−310	−930
Perc'ts	0	−2	−2	−1	−1	−2	+3	0	+2	−3	−4	−3	−3	−3	−3
II. Ditto; digestible dry matter in excess of 15.5 pounds. (68 comparisons.)															
A	1.34	9.0	25.9	0.89	6.2	17.1	0.13	0.92	2.53	0.71	4.8	13.8	1554	10507	30124
B	1.36	9.1	25.8	0.91	6.2	17.1	0.14	0.94	2.57	0.72	4.9	13.8	1564	10620	30170
B±A	+0.02	+0.1	−0.1	+0.02	0	0	+0.01	+0.02	+0.04	+0.01	+0.1	0	+10	+113	+46
Perc'ts	+1	+1	0	+2	0	0	+3	+2	+1	+1	+2	0	+1	+1	0
III. Ditto; digestible dry matter less than 15.5 pounds. (15 comparisons.)															
A	1.38	9.6	27.7	0.92	5.6	18.1	0.13	0.84	2.42	0.74	5.2	14.9	1600	11120	32000
B	1.39	9.6	27.7	0.91	5.5	18.3	0.12	0.84	2.41	0.74	5.2	14.9	1584	11150	32060
B±A	+0.01	0	0	−0.01	−0.1	+0.2	−0.01	0	−0.01	0	0	0	−16	+30	+60
Perc'ts	+1	0	0	−1	−1	+1	−2	0	−1	0	0	0	−1	+0	0
IV. Rations changed; total dry matter, 0; digestible dry matter, 0; digestible protein, 0; digestible carbohydrates, 0; calories, 0; nutritive ratio, 0; digestible dry matter in excess of 15.5 pounds. (85 comparisons).															
A	1.33	9.2	26.3	0.88	6.1	17.5	0.18	0.85	2.40	0.72	5.0	14.6	1551	10870	31600
B	1.32	9.1	26.0	0.89	6.1	17.5	0.18	0.88	2.50	0.72	5.0	14.4	1564	10910	31140
B±A	−0.01	−0.1	−0.3	+0.01	0	0	0	+0.03	+0.10	0	0	−0.2	+13	+40	−460
Perc'ts	−1	−1	−1	+1	0	0	+3	+4	+4	0	0	−1	+1	+0	−1

	Food consumption: Total dry matter	Food consumption: Digestible dry matter	Food consumption: Digestible protein	Food consumption: Digestible carbohydrates	Food consumption: Nutritive ratio	Food consumption: Calories	Production: Milk	Production: Total solids	Production: Fat	Production: Total solids	Production: Fat	Cost of food to make 1 lb. of: Milk	Cost of food to make 1 lb. of: Total solids	Cost of food to make 1 lb. of: Fat
	lbs	lbs	lbs	lbs	1:		lbs	%	%	lbs	lbs	cts	cts	cts

V. Rations changed; amounts of total and digestible dry matter, of digestible carbohydrates and of calories unchanged; and of digestible protein slightly decreased; nutritive ratio widened; digestible dry matter less than 15.5 pounds. (10 comparisons.)

A	22.1	15.0	2.13	13.1	6.4	28330	14.1	14.36	5.00	2.02	0.70	1.33	9.4	27.5
B	22.4	15.0	1.92	13.1	7.2	27930	13.9	14.37	4.99	1.98	0.68	1.25	8.7	25.2
B ± A	+0.3	0	−0.21	0	+0.8	−400	−0.2	+0.01	−0.01	−0.04	−0.02	−0.08	−0.7	−2.3
Perc'ts	+1	0	−10	0	+13	−1	−2	0	0	−2	−3	−6	−6	−8

VI. No change in rations; amounts of total and digestible dry matter, of digestible carbohydrates and of calories increased; amount of digestible protein unchanged; nutritive ratio widened. (13 comparisons.)

A	25.8	17.2	2.59	14.7	5.9	32160	22.5	14.84	5.14	3.32	1.15	0.78	5.2	15.1
B	27.3	18.1	2.54	15.6	6.3	33740	22.5	14.80	5.15	3.32	1.15	0.80	5.4	15.5
B ± A	+1.5	+0.9	−0.05	+0.9	+0.4	+1580	0	−0.04	+0.01	0	0	+0.02	+0.2	+0.4
Perc'ts	+6	+5	−2	+6	+7	+5	0	0	0	0	0	+3	+4	+3

VII. Rations changed; amounts of total and digestible dry matter, of digestible carbohydrates and of calories increased; amounts of digestible protein unchanged; nutritive ratio widened. (6 comparisons.)

A	26.7	17.9	2.36	15.8	6.9	33780	21.8	14.74	5.11	3.23	1.13	0.67	4.5	13.2
B	29.2	19.6	2.37	17.4	7.5	36770	22.0	14.57	5.08	3.21	1.12	0.71	4.9	14.2
B ± A	+2.5	+1.7	+0.01	+1.6	+0.6	+2900	+0.2	−0.17	−0.03	−0.02	−0.01	+0.04	+0.4	+1.0
Perc'ts	+9	+9	0	+10	+9	+9	+1	−1	−1	−1	−1	+6	+8	+8

VIII. No change in rations; amounts of total and digestible dry matter, of digestible carbohydrates and of calories decreased; amounts of digestible protein unchanged; nutritive ratio narrowed. (21 comparisons.)

A	27.4	18.1	2.67	15.7	6.0	34170	20.3	14.61	5.11	2.92	1.01	0.96	6.6	19.8
B	26.0	17.4	2.66	15.0	5.7	32860	19.9	14.55	5.07	2.84	0.98	0.99	6.9	20.3
B ± A	−1.4	−0.7	−0.01	−0.7	−0.3	−1310	−0.4	−0.06	−0.04	−0.08	−0.03	+0.03	+0.3	+0.5
Perc'ts	−5	−4	0	−5	−5	−4	−2	−1	−1	−3	−3	+3	+5	+3

	Total dry matter to make 1 lb. of			Digestible dry matter to make 1 lb. of			Digestible protein to make 1 lb. of			Digestible carbohydrates to make 1 lb. of			Calories to make 1 lb. of		
	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat
	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	cal	cal	cal

V. Rations changed; total dry matter, 0; digestible dry matter, 0; digestible protein, —; digestible carbohydrates, 0; calories, 0; nutritive ratio, +; digestible dry matter less than 15.5 pounds. (10 comparisons.)

A	1.60	11.6	32.5	1.09	7.6	21.9	0.15	1.07	3.08	0.93	6.5	18.7	2009	14030	40470
B	1.67	12.0	33.7	1.12	7.8	22.5	0.14	0.99	2.84	0.94	6.6	19.3	2009	14140	41079
± A	+0.07	+0.4	+1.2	+0.03	+0.2	+0.6	—0.01	—0.08	—0.24	+0.01	+0.1	+0.6	0	+110	+609
Perc'ts	+4	+3	+4	+3	+3	+3	—9	—8	—8	+1	+1	+3	0	+1	+1

VI. Rations same; total dry matter, +; digestible dry matter, +; digestible protein, 0; digestible carbohydrates, +; calories, +; nutritive ratio, +. (13 comparisons.)

A	1.22	8.2	23.7	0.80	5.4	15.6	0.12	0.80	2.33	0.65	4.4	12.8	1429	9688	27965
B	1.29	8.8	25.2	0.86	5.8	16.6	0.12	0.81	2.34	0.69	4.7	13.6	1499	10163	29840
B ± A	+0.07	+0.6	+1.5	+0.06	+0.4	+1.0	0	+0.01	+0.01	+0.04	+0.3	+0.8	+70	+475	+1875
Perc'ts	+6	+7	+6	+7	+7	+6	0	+1	0	+6	+7	+6	+5	+4	+5

VII. Rations changed; total dry matter, +; digestible dry matter, +; digestible protein, 0; digestible carbohydrates, +; calories, +; nutritive ratio, +. (6 comparisons.)

A	1.25	8.5	24.8	0.84	5.7	16.	0.11	0.75	2.25	0.72	4.9	14.0	1550	10458	29895
B	1.34	9.3	26.7	0.90	6.2	17.9	0.11	0.75	2.17	0.79	5.4	15.5	1671	11455	32830
B ± A	+0.09	+0.8	+1.9	+0.06	+0.5	+1.4	0	0	—0.08	+0.07	+0.5	+1.5	+121	+997	+2935
Perc'ts	+7	+9	+8	+7	+9	+8	+2	0	—3	+9	+9	+10	+7	+9	+9

VIII. Rations same; total dry matter, —; digestible dry matter, —; digestible protein, 0; digestible carbohydrates, —; calories, —; nutritive ratio, —. (21 comparisons.)

A	1.50	10.2	29.6	0.98	6.6	19.4	0.14	0.98	2.83	0.77	5.4	15.5	1683	11715	33830
B	1.43	9.8	28.6	0.96	6.6	18.8	0.14	0.99	2.89	0.75	5.3	15.3	1651	11570	33531
B ± A	—0.07	—0.4	—1.0	—0.02	0	—0.6	0	+0.01	+0.06	—0.02	—0.1	—0.2	—32	—145	—299
Perc'ts	—5	—4	—3	—2	0	—3	0	+1	+2	—3	—1	—1	—2	—1	—1

	Food consumption						Production					Cost of food to make 1 lb. of		
	Total dry matter	Digestible dry matter	Digestible protein	Digestible carbohydrates	Nutritive ratio	Calories	Milk	Total solids	Fat	Total solids	Fat	Milk	Total solids	Fat
	lbs	lbs	lbs	lbs	1:		lbs	%	%	lbs	lbs	cts	cts	cts
IX. Rations changed; amounts of total and digestible dry matter, of digestible carbohydrates and of calories decreased; amounts of digestible protein unchanged; nutritive ratio narrowed. (13 comparisons.)														
A	27.7	18.7	2.29	16.5	7.8	34950	17.5	14.66	5.28	2.54	0.89	1.05	7.2	20.5
B	25.7	17.0	2.31	14.8	6.6	31825	17.6	14.63	5.28	2.55	0.90	1.05	7.2	20.6
B ± A	−2.0	−1.7	+0.02	−1.7	−0.7	−3125	+0.1	−0.03	0	+0.01	+0.01	0	0	+0.1
Perc'ts	−7	−9	+1	−10	−9	−9	0	0	0	0	+1	0	0	0
X. No change in rations; amounts of total and digestible dry matter, of digestible carbohydrates and of calories unchanged; amounts of digestible protein slightly increased; nutritive ratio narrowed. (20 comparisons.)														
A	26.6	17.7	2.62	15.3	6.1	33330	23.3	14.67	5.15	3.36	1.17	0.76	5.2	15.1
B	26.6	17.8	2.78	15.2	5.7	33440	23.1	14.63	5.13	3.36	1.17	0.77	5.3	15.4
B ± A	0	+0.1	+0.16	−0.1	−0.4	+110	−0.2	−0.04	−0.02	0	0	+0.01	+0.1	+0.3
Perc'ts	0	0	+6	0	−6	0	−1	0	0	0	0	+1	+2	+2
XI. Rations changed; amounts of total and digestible dry matter and of calories unchanged; amounts of digestible carbohydrates slightly decreased; amounts of digestible protein increased; nutritive ratio narrowed. (20 comparisons.)														
A	26.3	17.7	2.15	15.8	7.8	33390	20.7	14.78	5.29	3.03	1.03	0.80	5.4	15.2
B	26.2	17.8	2.64	15.5	6.1	33760	21.7	14.65	5.22	3.15	1.11	0.81	5.5	15.6
B ± A	−0.1	+0.1	+0.49	−0.3	−1.7	+370	+1.0	−0.13	−0.07	+0.12	+0.08	+0.01	+0.1	+0.4
Perc'ts	0	0	+23	−2	−22	+1	+5	−1	−1	+4	+8	+1	+2	+2
XII. Rations unchanged; amounts of total and digestible dry matter, of digestible carbohydrates and of calories unchanged; amounts of digestible protein slightly decreased; nutritive ratio widened. (11 comparisons.)														
A	27.3	18.0	2.84	15.3	5.6	33740	21.9	14.43	4.96	3.15	1.08	0.83	5.8	17.0
B	27.2	17.8	2.64	15.3	6.0	33370	21.1	14.59	5.13	3.02	1.06	0.86	6.0	17.0
B ± A	−0.1	−0.2	−0.20	0	+0.4	−370	−0.8	+0.16	+0.17	−0.13	−0.02	+0.03	+0.2	0
Perc'ts	0	−1	−7	0	+7	−1	−4	+1	+3	−4	−2	+4	+3	+1

	Total dry matter to make 1 lb. of			Digestible dry matter to make 1 lb. of			Digestible protein to make 1 lb. of			Digestible carbohydrates to make 1 lb. of			Calories to make 1 lb. of		
	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat
	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	cal	cal	cal

IX. Rations changed; total dry matter, —; digestible dry matter, —; digestible protein, 0; digestible carbohydrates, —; calories, —; nutritive ratio, —. (13 comparisons.)

A	1.66	11.4	32.2	1.18	7.7	21.6	0.14	0.93	2.67	0.94	6.5	18.5	1997	13760	39270
B	1.57	10.7	30.5	1.08	7.0	19.9	0.14	0.95	2.73	0.84	5.8	16.4	1808	12480	35360
B ± A	—0.09	—0.7	—1.7	—0.10	—0.7	—1.7	0	+0.02	+0.06	—0.10	—0.7	—2.1	—189	—1280	—3910
Perc'ts	—5	—6	—5	—9	—9	—8	+2	+2	+2	—12	—13	—13	—10	—10	—11

X. Rations same; total dry matter, 0; digestible dry matter, 0; digestible protein, +; digestible carbohydrates, 0; calories, 0; nutritive ratio, —. (20 comparisons.)

A	1.25	8.5	24.4	0.83	5.6	16.3	0.12	0.80	2.33	0.66	4.6	13.1	1431	9920	28490
B	1.26	8.6	24.9	0.84	5.7	16.6	0.13	0.88	2.55	0.66	4.5	13.0	1448	9952	28581
B ± A	+0.01	+0.1	+0.5	+0.01	+0.1	+0.3	+0.01	+0.08	+0.22	0	—0.1	—0.1	+17	+32	+91
Perc'ts	+1	+1	+2	+1	+2	+2	+8	+10	+10	0	—2	—1	+1	+0	0

XI. Rations changed; total dry matter, 0; digestible dry matter, 0; digestible protein, +; digestible carbohydrates, —; calories, 0; nutritive ratio, —. (20 comparisons.)

A	1.33	9.0	25.2	0.90	6.1	17.1	0.11	0.73	2.04	0.76	5.2	14.6	1613	11020	30916
B	1.28	8.8	24.8	0.87	5.9	16.8	0.13	0.89	2.52	0.71	4.9	14.0	1556	10718	30415
B ± A	—0.05	—0.2	—0.4	—0.03	—0.2	—0.3	+0.02	+0.16	+0.48	—0.05	—0.3	—0.6	—57	—302	—501
Perc'ts	—4	—2	—2	—3	—2	—2	+22	+22	+24	—7	—6	—4	—4	—3	—2

XII. Rations same; total dry matter, 0; digestible dry matter, 0; digestible protein, —; digestible carbohydrates, 0; calories, 0; nutritive ratio +. (11 comparisons.)

A	1.35	9.4	27.5	0.89	6.2	18.1	0.14	0.96	2.79	0.70	4.9	14.2	1541	10711	31240
B	1.43	9.8	28.2	0.93	6.4	18.5	0.14	0.93	2.68	0.73	5.1	14.4	1582	11050	31480
B ± A	+0.08	+0.4	+0.7	+0.04	+0.2	+0.4	0	—0.03	—0.11	+0.03	+0.2	+0.2	+41	+339	+240
Perc'ts	+6	+5	+3	+4	+3	+2	—2	—3	—4	+4	+4	+1	+3	+3	+1

	Food consumption						Production					Cost of food to make 1 lb. of		
	Total dry matter	Digestible dry matter	Digestible protein	Digestible carbohydrates	Nutritive ratio	Calories	Milk	Total solids	Fat	Total solids	Fat	Milk	Total solids	Fat
	lbs	lbs	lbs	lbs	1:		lbs	%	%	lbs	lbs	cts	cts	cts
XIII. Rations changed; amounts of total and digestible dry matter and of calories unchanged; amount of digestible protein decreased; amounts of digestible carbohydrates slightly increased; nutritive ratio widened. (8 comparisons.)														
A	25.2	17.3	2.47	15.2	6.3	32870	20.8	14.16	4.79	2.91	0.98	0.94	6.6	19.6
B	25.1	17.2	2.04	15.5	8.1	32620	20.2	14.21	4.81	2.84	0.95	0.85	5.9	17.6
B ± A	—0.1	—0.1	—0.43	+0.3	+1.8	—250	—0.6	+0.05	+0.02	—0.07	—0.03	—0.09	— 0.7	—2.0
Perc'ts	0	—1	—17	+2	+29	—1	—3	0	0	—2	—3	—10	—11	—10
XIV. Rations unchanged; amounts of total and digestible dry matter of digestible protein, digestible carbohydrates and of calories increased; nutritive ratio decreased. (45 comparisons.)														
A	27.2	17.9	2.46	15.5	6.5	33400	23.8	14.77	5.17	3.48	1.21	0.73	5.0	13.9
B	29.4	19.3	2.82	16.8	6.2	36490	24.8	14.80	5.19	3.60	1.27	0.74	5.0	13.9
B ± A	+2.2	+1.4	+0.36	+1.3	—0.3	+3090	+1.0	+0.03	+0.02	+0.12	+0.06	+0.01	0	0
Perc'ts	+8	+8	+15	+8	—5	+9	+4	0	0	+3	+5	0	0	0
XV. Rations changed; amounts of total and digestible dry matter, of digestible protein, digestible carbohydrates and of calories increased; nutritive ratio narrowed. (143 comparisons.)														
A	25.3	16.6	2.18	14.5	7.1	31030	20.9	14.58	5.13	3.00	1.05	0.79	5.3	15.3
B	28.0	18.7	2.92	16.0	5.7	35190	21.9	14.63	5.17	3.17	1.12	0.84	5.8	16.4
B ± A	+2.7	+2.1	+0.74	+1.5	—1.4	+4160	+1.0	+0.05	+0.04	+0.17	+0.07	+0.05	+0.5	+1.1
Perc'ts	+11	+13	+34	+10	—20	+13	+5	0	1	+6	+7	+6	+8	+7
XVI. Ditto; digestible dry matter less than 15.5 pounds. (18 comparisons.)														
A	21.0	13.7	1.87	12.0	6.7	25800	15.6	14.98	5.41	2.26	0.81	1.10	7.2	19.9
B	22.0	14.5	2.21	12.5	5.9	27360	16.3	14.83	5.36	2.35	0.84	1.11	7.4	20.3
B ± A	+1.0	+0.8	+0.34	+0.5	—0.8	+1560	+0.7	—0.10	—0.05	+0.09	+0.03	+0.01	+0.2	+0.4
Perc'ts	+5	+6	+18	+4	—12	+6	+5	—1	—1	+4	+4	+1	+1	+2

	Total dry matter to make 1 lb. of			Digestible dry matter to make 1 lb. of			Digestible protein to make 1 lb. of			Digestible carbohydrates to make 1 lb. of			Calories to make 1 lb. of		
	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat
	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	cal	cal	cal
XIII. Ration changed; total dry matter, 0; digestible dry matter, 0; digestible protein, —; digestible carbohydrates, 0; calories, 0; nutritive ratio, +. (8 comparisons.)															
A	1.31	9.2	27.0	0.88	6.2	18.4	0.13	0.90	2.54	0.78	5.2	15.5	1580	11295	33540
B	1.34	9.5	27.7	0.92	6.4	19.2	0.11	0.75	2.13	0.77	5.5	16.3	1615	11486	34340
B ± A	+0.03	+0.3	+0.7	+0.04	+0.2	+0.8	−0.02	−0.15	−0.41	+0.04	+0.3	+0.8	+35	+191	+800
Perc'ts	+2	+3	+3	+5	+3	+4	−16	17	−16	+5	+6	+5	+2	+2	+2
XIV. Rations same; total dry matter, +; digestible dry matter, +; digestible protein, +; digestible carbohydrates, +; calories, +; nutritive ratio, —. (45 comparisons.)															
A	1.22	8.3	23.5	0.80	5.3	15.4	0.11	0.74	2.11	0.65	4.5	12.8	1403	9599	27610
B	1.27	8.6	24.4	0.83	5.6	16.1	0.12	0.82	2.32	0.68	4.7	13.2	1472	10188	28731
B ± A	+0.05	+0.3	+0.9	+0.03	+0.3	+0.7	+0.01	+0.08	+0.21	+0.03	+0.2	+0.4	+69	+589	+1121
Perc'ts	+4	+4	+4	+4	+5	+5	+10	+11	+11	+4	+4	+3	+5	+5	+4
XV. Rations changed; total dry matter, +; digestible dry matter, +; digestible protein, +; digestible carbohydrates, +; calories, +; nutritive ratio, —. (143 comparisons.)															
A	1.36	9.0	25.8	0.86	5.9	16.8	0.11	0.77	2.16	0.69	4.8	13.8	1485	10343	29551
B	1.40	9.3	26.6	0.92	6.3	17.7	0.14	0.96	2.71	0.73	5.0	14.3	1607	11100	31420
B ± A	+0.04	+0.3	+0.8	+0.06	+0.4	+0.9	+0.03	+0.19	+0.55	+0.04	+0.2	+0.5	+122	+757	+1869
Perc'ts	+3	+3	+3	+7	+7	−5	+25	+25	+25	+5	+4	+4	+8	+7	+6
XVI. Ditto; digestible dry matter less than 15.5 pounds. (18 comparisons.)															
A	1.55	10.2	28.3	1.01	6.7	18.5	0.14	0.94	2.55	0.77	5.3	14.8	1654	11416	31850
B	1.55	10.3	28.5	1.02	6.8	18.9	0.16	1.06	2.92	0.77	5.3	14.9	1678	11641	32570
B ± A	0	+0.1	+0.2	+0.01	+0.1	+0.4	+0.02	+0.12	+0.37	0	0	+0.1	+24	+225	+720
Perc'ts	0	+1	+1	+1	+1	+2	+14	+13	+15	0	0	+1	+1	+2	+2

	Food consumption						Production					Cost of food to make 1 lb. of		
	Total dry matter	Digestible dry matter	Digestible protein	Digestible carbohydrates	Nutritive ratio	Calories	Milk	Total solids	Fat	Total solids	Fat	Milk	Total solids	Fat
	lbs	lbs	lbs	lbs	1:		lbs	%	%	lbs	lbs	cts	cts	cts
XVII. Rations changed; amounts of total and digestible dry matter, of digestible protein, digestible carbohydrates and of calories increased; nutritive ratio narrowed; digestible dry matter increased from less than to more than 15.5 pounds. (38 comparisons.)														
A	23.0	14.9	1.83	13.1	7.4	27970	17.0	14.63	5.18	2.47	0.85	0.88	5.9	16.7
B	25.7	17.1	2.49	14.8	6.3	32160	17.8	14.75	5.26	2.61	0.91	0.93	6.3	17.7
B ± A	+2.7	+2.2	+0.66	+1.7	−1.1	+4190	+0.8	+0.12	+0.08	+0.14	+0.06	+0.05	+0.4	+1.0
Perc'ts	+12	+15	+36	+13	−16	+15	+5	+1	+2	+6	+7	+6	+7	+6
XVIII. Rations unchanged; amounts of total and digestible dry matter, of digestible protein, digestible carbohydrates and of calories increased: nutritive ratio slightly narrowed; digestible dry matter in excess of 15.5 pounds. (52 comparisons.)														
A	27.6	18.1	2.59	15.8	6.3	34200	25.2	14.71	5.14	3.68	1.27	0.70	4.7	13.5
B	29.3	19.4	2.81	16.8	6.2	36480	25.6	14.74	5.16	3.74	1.31	0.69	4.7	13.3
B ± A	+1.7	+1.3	+0.22	+1.0	−0.8	+2280	+0.4	+0.03	+0.02	+0.06	+0.04	−0.01	0	−0.2
Perc'ts	+6	+7	+9	+6	−5	+7	+2	0	0	+2	+3	−1	0	−1
XIX. Rations changed; amounts of total and digestible dry matter, of digestible protein, digestible carbohydrates and of calories increased; nutritive ratio narrowed; digestible dry matter in excess of 15.5 pounds. (173 comparisons.)														
A	26.9	17.7	2.43	15.5	6.7	33350	22.3	14.61	5.15	3.20	1.12	0.75	5.1	14.7
B	28.7	19.2	2.83	16.6	6.2	36140	23.2	14.71	5.20	3.32	1.16	0.78	5.3	15.2
B ± A	+1.8	+1.5	+0.40	+1.1	−0.5	+2790	+0.9	+0.10	+0.05	+0.12	+0.04	+0.03	+0.2	+0.5
Perc'ts	+7	+8	+16	+7	−8	+8	+4	+1	+1	+4	+4	+4	+4	+3
XX. Rations unchanged; amounts of total and digestible dry matter, of digestible protein, digestible carbohydrates and of calories decreased; nutritive ratio unchanged. (70 comparisons.)														
A	28.3	18.9	2.87	16.3	5.8	35650	18.8	15.33	5.56	2.87	1.04	1.02	6.7	18.1
B	26.0	17.5	2.60	15.0	5.7	32740	17.9	15.45	5.66	2.72	0.99	1.04	6.8	18.5
B ± A	−2.3	−1.4	−0.27	−1.3	−0.1	−2910	−0.9	+0.12	+0.10	−0.15	−0.05	+0.02	+0.1	+0.4
Perc'ts	−8	−7	−9	−8	−2	−8	−5	+1	+2	−5	−5	+3	+2	+2

XVII. Rations changed; total dry matter, +; digestible dry matter, +: digestible protein, +; digestible carbohydrates, +; calories, +; nutritive ratio —. (38 comparisons.)

	Total dry matter to make 1 lb. of: Milk	Total solids	Fat	Digestible dry matter to make 1 lb. of: Milk	Total solids	Fat	Digestible protein to make 1 lb. of: Milk	Total solids	Fat	Digestible carbohydrates to make 1 lb. of: Milk	Total solids	Fat	Calories to make 1 lb. of: Milk	Total solids	Fat
	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	cal	cal	cal
A	1.48	10.0	28.8	0.94	6.4	18.2	0.12	0.80	2.22	0.77	5.8	15.4	1645	11823	32910
B	1.55	10.5	29.4	1.03	7.0	19.7	0.15	1.00	2.83	0.83	5.7	16.3	1807	12821	35340
B ± A	+0.07	+0.5	+1.1	+0.09	+0.6	+1.5	+0.03	+0.20	+0.61	+0.06	+0.4	+0.9	+162	+998	+2430
Perc'ts	+5	+5	+4	+10	+9	+8	+25	+25	+27	+7	+7	+6	+9	+8	+7

XVIII. Rations same; total dry matter, +; digestible dry matter, +; digestible protein, +; digestible carbohydrates, +; calories, +; nutritive ratio —. (52 comparisons.)

	Total dry matter to make 1 lb. of: Milk	Total solids	Fat	Digestible dry matter to make 1 lb. of: Milk	Total solids	Fat	Digestible protein to make 1 lb. of: Milk	Total solids	Fat	Digestible carbohydrates to make 1 lb. of: Milk	Total solids	Fat	Calories to make 1 lb. of: Milk	Total solids	Fat
A	1.16	7.9	22.6	0.76	5.2	14.8	0.11	0.73	2.08	0.63	4.3	12.4	1357	9294	26930
B	1.20	8.1	23.2	0.79	5.4	15.3	0.12	0.78	2.21	0.66	4.5	12.8	1425	9754	27850
B ± A	+0.04	+0.2	+0.6	+0.03	+0.2	+0.5	+0.01	+0.05	+0.13	+0.03	+0.2	+0.4	+68	+460	+920
Perc'ts	+4	+4	+3	+4	+4	+3	+8	+6	+6	+5	+4	+3	+5	+5	+3

XIX. Rations changed; total dry matter, +; digestible dry matter, +; digestible protein, +; digestible carbohydrates, +; calories, +; nutritive ratio —. (173 comparisons.)

	Total dry matter to make 1 lb. of: Milk	Total solids	Fat	Digestible dry matter to make 1 lb. of: Milk	Total solids	Fat	Digestible protein to make 1 lb. of: Milk	Total solids	Fat	Digestible carbohydrates to make 1 lb. of: Milk	Total solids	Fat	Calories to make 1 lb. of: Milk	Total solids	Fat
A	1.30	8.9	25.5	0.85	5.8	16.5	0.12	0.80	2.27	0.70	4.8	13.8	1496	10425	29775
B	1.34	9.1	26.0	0.90	6.1	17.4	0.13	0.90	2.55	0.72	5.0	14.3	1558	10886	31153
B ± A	+0.04	+0.2	+0.5	+0.05	+0.3	+0.9	+0.01	+0.10	+0.28	+0.02	+0.2	+0.5	+62	+461	+1378
Perc'ts	+3	+2	+2	+6	+5	+5	+13	+12	+12	+3	+4	+4	+4	+4	+4

XX. Rations same; total dry matter, —; digestible dry matter, —; digestible protein, —; digestible carbohydrates, —; calories, —; nutritive ratic 0. (70 comparisons.)

	Total dry matter to make 1 lb. of: Milk	Total solids	Fat	Digestible dry matter to make 1 lb. of: Milk	Total solids	Fat	Digestible protein to make 1 lb. of: Milk	Total solids	Fat	Digestible carbohydrates to make 1 lb. of: Milk	Total solids	Fat	Calories to make 1 lb. of: Milk	Total solids	Fat
A	1.58	10.3	28.5	1.05	7.0	18.9	0.16	1.06	2.84	0.87	5.7	15.7	1896	12422	34280
B	1.54	10.0	27.6	1.04	6.9	18.3	0.15	1.02	2.79	0.84	5.5	15.2	1829	12038	33070
B ± A	—0 04	—0.3	—0.9	—0.01	—0.1	—0.6	—0.01	—0 04	—0.05	—0.03	—0.2	—0.5	—67	—384	—1210
Perc'ts	—3	—3	—3	—1	—1	—3	—2	—3	—2	—3	—4	—3	—4	—3	—4

	Food consumption						Production					Cost of food to make 1 lb. of		
	Total dry matter	Digestible dry matter	Digestible protein	Digestible carbohydrates	Nutritive ratio	Calories	Milk	Total solids	Fat	Total solids	Fat	Milk	Total solids	Fat
	lbs	lbs	lbs	lbs	1:		lbs	%	%	lbs	lbs	cts	cts	cts
XXI. Rations changed; amounts of total and of digestible dry matter, of digestible protein, digestible carbohydrates and of calories decreased; nutritive ratio widened. (217 comparisons.)														
A	27.9	18.8	2.88	16.1	5.8	35300	21.2	14.85	5.29	3.05	1.08	0.89	6.0	17.0
B	25.3	16.8	2.19	14.7	7.1	31420	19.2	14.83	5.31	2.81	1.00	0.87	5.8	16.4
B ± A	—2.6	—2.0	—0.69	—1.4	+1.3	—3880	—2.0	—0.02	+0.02	—0.24	—0.08	—0.02	—0.2	—0.6
Perc'ts	—9	—11	—24	—9	+23	—11	—9	0	0	—8	—7	—2	—3	—4
XXII. Rations changed; amounts of total and digestible dry matter, of digestible protein, digestible carbohydrates and of calories decreased; nutritive ratio unchanged; digestible dry matter less than 15.5 pounds. (22 comparisons.)														
A	22.2	14.6	2.16	12.6	6.0	27450	15.2	14.76	5.24	2.23	0.79	1.14	7.7	21.6
B	20.6	13.5	1.95	11.4	6.2	24830	14.3	14.79	5.30	2.10	0.74	1.11	7.4	20.9
B ± A	—1.6	—1.1	—0.21	—1.2	+0.2	—2620	—0.9	+0.03	+0.06	—0.13	—0.05	—0.03	—0.3	—0.7
Perc'ts	—7	—8	—10	—10	+3	—10	—6	0	+1	—6	—6	—3	—3	—3
XXIII. Rations unchanged; amounts of total and digestible dry matter, of digestible protein, digestible carbohydrates and of calories decreased; nutritive ratio unchanged; digestible dry matter decreased from more than to less than 15.5 pounds. (9 comparisons.)														
A	24.6	16.4	2.47	14.2	5.7	31010	14.0	15.47	5.63	2.14	0.77	1.31	8.4	23.5
B	22.0	14.8	2.29	12.7	5.5	27880	13.2	15.54	5.69	2.00	0.72	1.33	8.5	23.5
B ± A	—2.6	—1.6	—0.18	—1.5	—0.2	—3130	—0.8	+0.07	+0.06	—0.14	—0.05	+0.02	+0.1	0
Perc'ts	—11	—10	—7	—11	—3	—10	—7	0	+1	—7	—7	+2	+1	0
XXIV. Rations changed; amounts of total and digestible dry matter, of digestible protein, digestible carbohydrates and of calories decreased; nutritive ratio widened; digestible dry matter decreased from more than to less than 15.5 pounds. (50 comparisons.)														
A	25.6	17.0	2.61	14.6	5.9	32010	17.3	15.01	5.41	2.52	0.89	1.05	7.0	19.4
B	22.3	14.5	1.90	12.8	7.0	27340	16.1	14.87	5.37	2.32	0.82	0.97	6.5	17.9
B ± A	—3.3	—2.5	—0.71	—1.8	+1.1	—4670	—1.2	—0.14	—0.04	—0.20	—0.07	—0.08	—0.5	—1.5
Perc'ts	—13	—15	—27	—12	+19	—15	—7	—1	—1	—8	—8	—8	—7	—8

	Total dry matter to make 1 lb. of			Digestible dry matter to make 1 lb. of			Digestible protein to make 1 lb. of			Digestible carbohydrates to make 1 lb. of			Calories to make 1 lb. of		
	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat
	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	cal	cal	cal

XXI. Rations changed; total dry matter, —; digestible dry matter, —; digestible protein, —; digestible carbohydrates, —; calories, —; nutritive ratio +. (217 comparisons.)

A	1.46	9.8	27.7	0.98	6.7	18.5	0.15	1.00	2.83	0.76	5.8	14.9	1665	11574	32685
B	1 42	9.5	26.7	0.94	6.4	17.7	0.12	0.82	2.30	0 77	5.2	14.7	1637	11181	31420
B ± A	−0.04	−0.3	−1.0	−0.04	−0.3	−0.8	−0.03	−0.18	−0.53	+0.01	−0.1	−0.2	−28	−393	−1265
Perc'ts	−3	−3	−4	−4	−4	−4	−18	−18	−19	+1	−2	−1	−2	−3	−4

XXII. Rations changed; total dry matter, —; digestible dry matter, —; digestible protein, —; digestible carbohydrates, —; calories, —; nutritive ratio 0. (22 comparisons.)

A	1.58	10.7	30.4	1.05	7.2	20.0	0.16	1.07	2.95	0.83	5.7	16.0	1806	12310	34746
B	1.54	10.4	29.1	1.01	6.9	19.	0.15	1.03	2.79	0.80	5.4	15.4	1736	11824	33550
B ± A	−0 04	−0.3	−1.3	−0.04	−0.3	−1.0	−0.01	−0.04	−0.16	−0.03	−0.3	−0.6	−70	−486	−1196
Perc'ts	−3	−3	−4	−4	−4	−5	−4	−4	−5	−4	−6	−4	−4	−4	−3

XXIII. Rations same; total dry matter, —; digestible dry matter, —; digestible protein,, —; digestible carbohydrates, —; calories, —; nutritive ratio 0. (9 comparisons.)

A	1.90	12.1	33.5	1.24	8.0	22.3	0.19	1.21	3.38	1.01	6.6	18.4	2215	14490	40273
B	1.83	11.7	32.3	1 22	7.8	21.5	0.19	1.21	3.35	0.96	6.4	17.6	2112	13940	38720
B ± A	−0.07	−0.4	−1.2	−0.02	−0.2	−0.8	0	0	−0.03	−0.05	−0.2	−0.8	−103	−550	−1553
Perc'ts	−4	−3	−4	−2	−3	−4	+1	0	−1	−5	−3	−5	−5	−4	−4

XXIV. Rations changed; total dry matter, —; digestible dry matter, —; digestible protein, —; digestible carbohydrates, —; calories, —; nutritive ratio +. (50 comparisons.)

A	1.64	10.9	30.5	1.10	7.3	20.3	0.17	1.10	3 07	0.84	5.8	16.4	1850	12701	35969
B	1.52	10.3	28.7	1.00	6.6	18.7	0.13	0.88	2.40	0.80	5.5	15.6	1698	11784	33340
B ± A	−0.12	−0.6	−1.8	−0.10	−0.7	−1.6	−0.04	−0.22	−0.67	−0.04	−0.3	−0.8	−152	−917	−2629
Perc'ts	−7	−6	−6	−9	−9	−8	−23	−20	−22	−5	−5	−5	−9	−8	−8

	Food consumption						Production					Cost of food to make 1 lb. of		
	Total dry matter	Digestible dry matter	Digestible protein	Digestible carbohydrates	Nutritive ratio	Calories	Milk	Total solids	Fat	Total solids	Fat	Milk	Total solids	Fat
	lbs	lbs	lbs	lbs	1:		lbs	%	%	lbs	lbs	cts	cts	cts

XXV. Rations unchanged; amounts of total and digestible dry matter, of digestible protein, digestible carbohydrates and of calories decreased; nutritive ratio unchanged; digestible dry matter in excess of 15.5 pounds. (89 comparisons.)

A	28.4	19.1	2.81	16.5	6.0	35910	21.1	15.00	5.33	3.15	1.10	0.93	6.1	17.3
B	26.7	17.9	2.65	15.4	5.9	33570	20.4	15.04	5.37	3.05	1.08	0.96	6.3	17.8
B ± A	−1.7	−1.2	−0.16	−1.1	−0.1	−2340	−0.7	+0.04	+0.04	−0.10	−0.02	+0.03	+0.2	+0.5
Perc'ts	−6	−7	−6	−7	−1	−7	−3	0	+1	−3	−2	+3	+3	+3

XXVI. Rations changed; amounts of total and digestible dry matter, of digestible protein, digestible carbohydrates and of calories decreased; nutritive ratio slightly widened; digestible dry matter in excess of 15.5 pounds. (255 comparisons.)

A	28.8	19.4	2.77	16.9	6.4	36590	21.7	14.81	5.26	3.17	1.10	0.85	5.7	16.3
B	26.8	17.9	2.48	15.5	6.7	33650	20.9	14.86	5.33	3.02	1.07	0.86	5.8	16.3
B ± A	−2.0	−1.5	−0.29	−1.4	+0.3	−2940	−0.8	+0.05	+0.07	−0.15	−0.03	+0.01	+0.1	0
Perc'ts	−7	−8	−10	−8	+5	−8	−4	0	+1	−5	−3	+1	+2	0

XXVII. Rations changed; amounts of total and digestible dry matter, of digestible carbohydrates and of calories increased; amounts of digestible protein decreased; nutritive ratio widened. (29 comparisons.)

A	25.9	17.4	2.62	15.1	5.9	32960	22.0	14.45	5.05	3.15	1.09	0.80	5.5	15.9
B	27.5	18.5	2.20	16.4	7.8	34600	21.8	14.52	5.06	3.14	1.08	0.80	5.5	15.9
B ± A	+1.6	+1.1	−0.42	+1.3	+1.9	+1640	−0.2	+0.07	+0.01	−0.01	−0.01	0	0	0
Perc'ts	+6	+6	−16	+9	+32	+5	−1	0	0	0	−1	0	0	0

XXVIII. Rations unchanged; amounts of total and digestible dry matter, of digestible carbohydrates and of calories slightly decreased; amounts of digestible protein increased; nutritive ratio narrowed. (8 comparisons.)

A	29.4	19.4	2.88	16.9	5.9	36790	23.2	14.89	5.32	3.45	1.24	0.85	5.7	16.0
B	28.2	18.8	3.11	16.0	5.1	35540	23.2	14.90	5.35	3.47	1.25	0.87	5.8	16.4
B ± A	−1.2	−0.6	+0.23	−0.9	−0.8	−1250	0	+0.01	+0.03	+0.02	+0.01	+0.02	+0.1	+0.4
Perc'ts	−4	−3	+8	−5	−13	−3	0	0	+1	+1	+1	+2	+2	+3

	Total dry matter to make 1 lb. of			Digestible dry matter to make 1 lb. of			Digestible protein to make 1 lb. of			Digestible carbohydrates to make 1 lb. of			Calories to make 1 lb. of		
	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat
	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	cal	cal	cal
XXV. Rations same; total dry matter, —; digestible dry matter, —; digestible protein, —; digestible carbohydrates, —; calories, —; nutritive ratio 0. (89 comparisons.)															
A	1.45	9.6	27.0	0.97	6.5	18.1	0.14	0.97	2.65	0.78	5.2	15.0	1702	11400	32646
B	1.41	9.3	26.3	0.95	6.2	17.6	0.14	0.95	2.59	0.76	5.1	14.3	1646	11007	31083
B ± A	−0.04	−0.3	−0.7	−0.02	−0.3	−0.5	0	−0.02	−0.06	−0.02	−0.1	−0.7	−56	−393	−1563
Perc'ts	−3	−3	−3	−3	−4	−3	−3	−2	−2	−3	−2	−5	−3	−4	−5
XXVI. Rations changed; total dry matter, —; digestible dry matter, —; digestible carbohydrates, —; calories, —; nutritive ratio +. (255 comparisons.)															
A	1.42	9.6	27.2	0.98	6.4	18.5	0.14	0.92	2.56	0.78	5.3	15.4	1686	11543	33261
B	1.41	9.5	26.6	0.94	6.1	17.6	0.12	0.82	2.32	0.74	5.1	14.5	1610	11142	31450
B ± A	−0.01	−0.1	−0.6	−0.04	−0.3	−0.9	−0.02	−0.10	−0.24	−0.04	−0.2	−0.9	−76	−401	−1811
Perc'ts	0	−1	−2	−4	−5	−5	−10	−11	−9	−5	−4	−6	−5	−4	−6
XXVII. Rations changed; total dry matter, +; digestible dry matter, +; digestible protein, —; digestible carbohydrates, +; calories, +; nutritive ratio +. (29 comparisons.)															
A	1.25	8.6	24.8	0.84	5.8	16.6	0.13	0.87	2.51	0.69	4.8	13.9	1498	10463	30240
B	1.35	9.3	26.9	0.91	6.2	17.9	0.11	0.74	2.15	0.75	5.2	15.2	1587	11020	32040
B ± A	+0.10	+0.7	+2.1	+0.07	+0.4	+1.3	−0.02	−0.13	−0.36	+0.06	+0.4	+1.3	+89	+557	+1800
Perc'ts	+8	+8	+8	+8	+7	+8	−15	−15	−14	+8	+8	+9	+6	+5	+6
XXVIII. Rations same; total dry matter, —; digestible dry matter, —; digestible protein, +; digestible carbohydrates, —; calories, —; nutritive ratio —. (8 comparisons.)															
A	1.37	9.3	26.0	0.91	6.1	17.2	0.13	0.90	2.51	0.73	4.9	13.6	1586	10664	29670
B	1.31	8.8	24.6	0.87	5.9	16.4	0.14	0.96	2.68	0.69	4.6	12.8	1532	10243	28430
B ± A	−0.06	−0.5	−1.4	−0.04	−0.2	−0.8	+0.01	+0.06	+0.17	−0.04	−0.3	−0.8	−54	−421	−1240
Perc'ts	−4	−5	−5	−4	−3	−5	+9	+7	+7	−6	−7	−6	−4	−4	−4

	Food consumption: Total dry matter	Digestible dry matter	Digestible protein	Digestible carbohydrates	Nutritive ratio	Calories	Production: Milk	Total solids	Fat	Total solids	Fat	Cost of food to make 1 lb. of: Milk	Total solids	Fat
	lbs	lbs	lbs	lbs	1:		lbs	%	%	lbs	lbs	cts	cts	cts
XXIX. Rations changed; amounts of total and digestible dry matter, of digestible carbohydrates and of calories decreased; amounts of digestible protein increased; nutritive ratio narrowed. (63 comparisons.)														
A	27.8	19.0	2.29	16.8	7.7	35510	19.9	15.01	5.38	2.95	1.05	0.95	6.3	17.7
B	25.9	17.7	2.77	15.2	5.6	33430	19.6	15.12	5.47	2.93	1.05	0.96	6.4	17.8
B ± A	−1.9	−1.3	+0.48	−1.6	−2.1	−2080	−0.3	+0.11	+0.09	−0.02	0	+0.01	+0.1	+0.1
Perc'ts	−7	−7	+21	−10	−27	−6	−2	+1	+2	−1	0	+2	+2	0

	Total dry matter to make 1 lb. of: Milk	Total solids	Fat	Digestible dry matter to make 1 lb. of: Milk	Total solids	Fat	Digestible protein to make 1 lb. of: Milk	Total solids	Fat	Digestible carbohydrates to make 1 lb. of: Milk	Total solids	Fat	Calories to make 1 lb. of: Milk	Total solids	Fat
	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	cal	cal	cal
XXIX. Rations changed; total dry matter, —; digestible dry matter, —; digestible protein, +; digestible carbohydrates, —; calories, —; nutritive ratio —. (63 comparisons.)															
A	1.52	10.1	28.4	1.03	7.0	19.2	0.12	0.83	2.30	0.84	5.7	16.0	1784	12039	33820
B	1.45	9.6	26.4	0.97	6.5	17.7	0.15	1.02	2.81	0.78	5.2	14.5	1706	11410	31840
B ± A	−0.07	−0.5	−2.0	−0.06	−0.5	−1.5	+0.03	+0.19	+0.51	−0.06	−0.5	−1.5	−78	−629	−1980
Perc'ts	−5	−5	−7	−6	−7	−8	+24	+23	+22	−8	−10	−10	−5	−5	−6

The exact data as to food consumption, milk production, etc., are of interest, but of less importance as measures than are the percentage differences, since the latter show the results in concrete shape and on a definite basis. They are gathered into one table on page 361 and are condensed to the last degree. The first six columns—total dry matter to calories, inclusive—are direct transcripts of the main tables on pages 346-360; the seventh column, headed "quantity," shows the

CONDENSATION OF ESSENTIAL DATA OF TABLES ON PAGES 346-360

Table number	Food consumption							Production			Food consumption proportioned to production				
	Number of comparisons	Total dry matter	Digestible dry matter	Digestible protein	Digestible carbohydrates	Nutritive ratio	Calories	Quantity	Quality	Cost	Total dry matter	Digestible dry matter	Digestible protein	Digestible carbohydrates	Calories
I......	19	— 1	— 1	0	— 1	— 1	— 1	+ 2	0	— 2	— 1	— 1	+ 2	— 3	— 3
II......	68	— 1	0	+ 1	0	— 2	0	0	+ 1	+ 2	+ 1	+ 1	+ 2	+ 1	+ 1
III.....	15	— 1	— 1	— 3	— 1	+ 1	— 1	— 1	— 1	0	0	0	— 1	0	0
IV.....	85	— 1	0	+ 3	0	— 2	0	0	0	+ 1	— 1	0	+ 4	0	0
V......	10	+ 1	0	—10	0	+13	— 1	— 2	0	— 7	+ 4	+ 3	— 8	+ 2	+ 1
VI.....	13	+ 6	+ 5	— 2	+ 6	+ 7	+ 5	0	0	+ 3	+ 6	+ 7	0	+ 6	+ 5
VII....	6	+ 9	+ 9	0	+10	+ 9	+ 9	0	— 1	+ 7	+ 8	+ 8	0	+ 9	+ 8
VIII...	21	— 5	— 4	0	— 5	— 5	— 4	— 3	— 1	+ 4	— 4	— 2	+ 1	— 2	— 1
IX.....	13	— 7	— 9	+ 1	—10	— 9	— 9	0	0	0	— 5	— 9	+ 2	—13	—10
X......	20	0	0	+ 6	0	— 6	0	0	0	+ 2	+ 1	+ 2	+ 9	— 1	0
XI.....	20	0	0	+23	— 2	—22	+ 1	+ 4	— 1	+ 2	— 3	— 2	+23	— 6	— 3
XII....	11	0	— 1	— 7	0	+ 7	— 1	— 3	+ 2	+ 3	+ 5	+ 3	— 3	+ 3	+ 2
XIII...	8	0	— 1	—17	+ 2	+29	— 1	— 3	0	—10	+ 3	+ 4	—16	+ 5	+ 2
XIV....	45	+ 8	+ 8	+15	+ 8	— 5	+ 9	+ 4	0	0	+ 4	+ 5	+11	+ 4	+ 5
XV....	143	+11	+13	+34	+10	—20	+13	+ 6	+ 1	+ 7	+ 3	+ 6	+25	+ 4	+ 7
XVI....	18	+ 5	+ 6	+18	+ 4	—12	+ 6	+ 4	— 1	+ 1	+ 1	+ 1	+14	0	+ 2
XVII...	38	+12	+15	+36	+13	—16	+15	+ 6	+ 2	+ 6	+ 5	+ 9	+26	+ 7	+ 8
XVIII..	52	+ 6	+ 7	+ 9	+ 6	— 5	+ 7	+ 2	0	— 1	+ 4	+ 4	+ 7	+ 4	+ 4
XIX....	173	+ 7	+ 8	+16	+ 7	— 8	+ 8	+ 4	+ 1	+ 4	+ 2	+ 5	+12	+ 4	+ 4
XX....	70	— 8	— 7	— 9	— 8	— 2	— 8	— 5	+ 2	+ 2	— 3	— 2	— 2	— 3	— 4
XXI....	217	— 9	—11	—24	— 9	+23	—11	— 8	0	— 3	— 3	— 4	—18	— 1	— 8
XXII...	22	— 7	— 8	—10	—10	+ 3	—10	— 6	+ 1	— 3	— 3	— 4	— 4	— 5	— 4
XXIII..	9	—11	—10	— 7	—11	— 3	—10	— 7	+ 1	+ 1	— 4	— 3	0	— 4	— 4
XXIV..	50	—13	—15	—27	—12	+19	—15	— 8	— 1	— 8	— 6	— 9	—22	— 5	— 8
XXV...	89	— 6	— 7	— 6	— 7	— 1	— 7	— 3	+ 1	+ 3	— 3	— 3	— 2	— 3	— 4
XXVI..	255	— 7	— 8	—10	— 8	+ 5	— 8	— 4	+ 1	+ 1	— 1	— 5	—10	— 5	— 5
XXVII.	29	+ 6	+ 6	—16	+ 9	+32	+ 5	— 1	0	0	+ 8	+ 8	—15	+ 8	+ 6
XXVIII	8	— 4	— 3	+ 8	— 5	—13	— 3	+ 1	+ 1	+ 2	— 5	— 4	+ 8	— 6	— 4
XXIX..	63	— 7	— 7	+21	—10	—27	— 6	— 1	+ 2	+ 1	— 6	— 7	+28	— 9	— 5

average figures for milk, total solids and fat weights; the eighth, "quality," the average data for the percentages of total solids and fat; while the ninth to fourteenth give the averages of production proportioned to consumption. In but few instances only do these averages depart more than one percent from any of the component figures.

WHAT ARE THE TEACHINGS OF THESE CONCENTRATED DATA?

I. *As regards quality of milk.*—In only four out of twenty-nine cases was there a 2 percent change made in the quality of the milk; and in but a single case did the gain in quality exceed 0.10 percent fat. This case (XII) rests on only eleven comparisons; and 80 percent of the difference is located in only three of these eleven comparisons. The thesis that under normal conditions food changes do not affect the fat content of the milk has now become so thoroughly established as to need no further argument; yet such a weight of testimony as is here gathered has seldom been adduced and hence the emphasis laid upon it.

II. *As regards the relationship of food consumption and milk production.*—Tables I to IV represent in three cases identical rations, and in the fourth different ones; but in all cases the cows ate in each of the compared periods a close approximation to the same amounts of total dry matter, of digestible dry matter and of the sundry nutrients, and ingested the same numbers of calories of energy. Lactation shrinkage being allowed for the differences in outcome expressed as percentages should be nil. They should be notably less than in any of the remaining twenty-five cases where more or less decided variations in food consumption of some sort were made. And so they are! Of the 24 figures expressive of food consumption 7 are zeros, 13 are ones, 2 are twos and 2 are threes. Of the 32 having to do with production, 12 are zeros, 12 are ones, 5 are twos, 2 are threes and 1 a four, an average value of one, a figure far below any other occurring in the entire table. This comparison affords a good check as to the experimental error involved, for the reason just cited, that no such production figures occur elsewhere in the tables.

Taking up now each food consumption column by itself and discussing the results:

TOTAL DRY MATTER

Tables I-III. No change in rations, nor in amount or character of total or digestible nutrients. (19, 68 and 15 comparisons). Regardless of whether the amount of digestible dry matter eaten was above or below the Wolff standard (15.5 pounds), under these conditions,

identical results in yield (+2, 0, —1) and in weights of dry matter used to make a pound of product (—1, +1, 0).

Table IV. A change in rations, but no change in amount or character of total or digestible nutrients. (85 comparisons). Identical yield (0) and weight of dry matter used to make a pound of product (—1). More than 15.5 pounds of digestible nutrients fed.

Table V. A change in rations; no change in amount of total or digestible nutrients; change in character of same, protein dropping 10 percent. (10 comparisons). Slight drop in yield (—2); increase in weight used to make a pound of product. Less than 15.5 pounds of digestible dry matter fed.

Table VI. No change in rations; increase in amounts of total and all digestible nutrients except protein. (13 comparisons). Six percent increase in total dry matter consumption and in same per pound of product, but no increase in yield (0).

Table VII. A change in rations; increase in amount of total and all digestible nutrients except protein. (6 comparisons). Nine percent increase in total dry matter consumption, and 8 percent in the same per pound of product, but no increase in yield (0).

Table VIII. No change in rations; decrease in amount of total and all digestible nutrients except protein. (21 comparisons). Five percent decrease in total dry matter consumption, 4 percent in same per pound of product, and 3 percent in yield.

Table IX. A change in rations; decrease in amount of total and all digestible nutrients except protein. (13 comparisons). Seven percent decrease in total dry matter consumption, 5 percent in same per pound of product, but identical yields (0).

Why, in three of the four cases just cited, were changes in total and in digestible nutrient consumption, ranging from 5 to 9 percent, without apparent effect upon the yield? A survey of the data indicates that in each case the cows ate more of all the nutrients than is specified by any of the standards; in other words, they had plenty to eat in either event. Then, too, the protein supply was not changed, which may or may not have been a factor. These zeros stand out prominently in the column headed "quantity" in the table on page 361 and may perhaps have significance as a protein effect.

Table X. No change in rations, nor in amount of total or digestible nutrients except protein, which is increased. (20 comparisons). Identical yield (0) and weight of dry matter used to make a pound of product (+1).

Table XI. A change in rations; no change in amounts of total or digestible nutrients except protein, which is greatly increased. (20

comparisons). Four percent greater yield and 3 percent decrease in weight per pound of product.

Table XII. No change in rations, nor in amount of total or digestible nutrients except protein, which is decreased. (11 comparisons). Three percent less yield and 5 percent increase in weight per pound of product.

Table XIII. A change in rations; no change in amounts of total or digestible nutrients except protein, which is greatly decreased. (8 comparisons). Three percent less yield and 5 percent increase in weight per pound of product.

Table XIV. No change in rations, but total and all digestible nutrients increased. (45 comparisons). Eight percent increase in total dry matter consumption, accompanied by 4 percent increase in yield and in weight of dry matter per pound of yield.

Table XV. A change in rations; total and all digestible nutrients increased. (143 comparisons). Eleven percent increase in total dry matter consumption, accompanied by 6 percent increase in yield and 3 percent in weight of dry matter per pound of yield.

Table XVI. A change in rations; total and all digestible nutrients increased; digestible nutrients less than 15.5 pounds. (18 comparisons). Five percent increase in total dry matter consumption, accompanied by 4 percent increase in yield and 1 percent in weight of dry matter per pound of product.

Table XVII. A change in rations; total and all digestible nutrients increased; digestible nutrients increased from less than to more than 15.5 pounds. (38 comparisons). Twelve percent increase in total dry matter consumption, accompanied by 6 percent increase in yield and 5 percent increase in weight of dry matter per pound of product.

Table XVIII. No change in rations, but total and all digestible nutrients increased; digestible nutrients more than 15.5 pounds. (52 comparisons). Six percent increase in total dry matter consumption. accompanied by 2 percent increase in yield and 4 percent increase in weight of dry matter per pound of product.

Table XIX. A change in rations; total and all digestible nutrients increased; digestible nutrients more than 15.5 pounds. (173 comparisons). Seven percent increase in total dry matter consumption, accompanied by 2 percent increase in yield and 4 percent increase in weight of dry matter per pound of product.

Table XX. No change in rations, but total and all digestible nutrients decreased. (70 comparisons). Eight percent decrease in total dry matter consumption, accompanied by 5 percent decrease in yield and 3 percent decrease in weight of dry matter per pound of product.

Table XXI. A change in rations; total and all digestible nutrients decreased. (217 comparisons). Nine percent decrease in total dry matter consumption, accompanied by 8 percent decrease in yield and 3 percent decrease in weight of dry matter per pound of product.

Table XXII. A change in rations; total and all digestible nutrients decreased; digestible nutrients less than 15.5 pounds. (22 comparisons). Seven percent decrease in total dry matter consumption, accompanied by 6 percent decrease in yield and 3 percent in weight of dry matter per pound of product.

Table XXIII. No change in rations, but total and all digestible nutrients decreased; digestible nutrients decreased from more than to less than 15.5 pounds. (9 comparisons). Eleven percent decrease in total dry matter consumption, accompanied by 7 percent decrease in yield and 4 percent in weight of dry matter per pound of product.

Table XXIV. A change in rations; total and all digestible nutrients decreased; digestible nutrients decreased from more than to less than 15.5 pounds. (50 comparisons). Thirteen percent decrease in total dry matter consumption, accompanied by 8 percent decrease in yield and 6 percent in weight of dry matter per pound of product.

Table XXV. No change in rations, but total and all digestible nutrients decreased; digestible nutrients more than 15.5 pounds. (89 comparisons). Six percent decrease in total dry matter consumption, accompanied by 3 percent decrease in yield and 3 percent in weight of dry matter per pound of product.

Table XXVI. A change in rations; total and all digestible nutrients decreased; digestible nutrients more than 15.5 pounds. (255 comparisons). Seven percent decrease in total dry matter consumption, accompanied by 4 percent decrease in yield and 1 percent in weight of dry matter per pound of product.

Table XXVII. A change in rations; total and all digestible nutrients increased except protein, which is decreased. (29 comparisons). Six percent increase in total dry matter consumption, but 1 percent less yield; 8 percent increase in weight of total dry matter per pound of product.

Table XXVIII. No change in rations; total and all digestible nutrients decreased except protein, which is increased. (8 comparisons). Four percent decrease in total dry matter consumption, but 1 percent gain in yield; 5 percent decrease in weight of total dry matter per pound of product.

Table XXIX. A change in rations; total and all digestible nutrients decreased except protein, which is increased. (63 comparisons). Seven percent decrease in total dry matter consumption, accompanied

by 1 percent decrease in yield; 6 percent decrease in weight of total dry matter per pound of product.

DIGESTIBLE DRY MATTER

Since approximately two-thirds of the total dry matter in the average ration fed in these trials was digestible, it follows that when the one either increased, decreased or remained unchanged in the amount the other did likewise, and that the results in general expressed as percentages are essentially the same. In but one of the twenty-nine tables is there a difference between the two amounting to 3 percent (No. XVII), and in but four, differences amounting to 2 percent (Nos. IX, XV, XXI, XXIV), while in but three (Nos. IX, XVII, XXVI) are the figures showing weight of nutrients used per pound of product so unlike as to be 4 percent apart. Moreover, where divergencies do exist the larger differences are found in the digestible dry matter column. Hence one may say, subject to the limitations mentioned below, that all statements made on pages 362 to 366 under the heading "Total dry matter" apply likewise to the results arising from changes of digestible dry matter, consumption being, however, in the four cases cited above somewhat understated.

There is, however, one limitation to this general statement which ought to be mentioned and to which some of the data in hand appears to give countenance, viz.: *the effect of varying proportions of concentrates and roughage.* It is well understood that a greater proportion of the digestible dry matter is available for purposes of production ("net energy") in concentrates than in roughages. In cases such as those cited above (Tables IX, XV, XVII, XXI and XXIV), where the digestible dry matter variations resulting from ration changes were proportionately greater than those of the total dry matter to the extent of 2 or 3 percent, this divergence was due to differences in the proportions of roughage and concentrate. Now the question arises whether this difference in proportions was a factor in milk yield fluctuation. The following comparisons are suggestive in this connection. The choices for tables to compare with the five cited above were based, so far as might be, on similarity.

Table number	Comparisons	Dry matter	Digestible dry matter	Digestible protein	Milk yield	
VIII, IX	21 13	— 5 — 7	— 4 — 9	0 + 1	—2 0	A gain of 2% in milk yield in spite of fact that less concentrates were fed
XV	63 143	+ 7 +11	+ 7 +13	+17 +34	+5 +5	No effect.
XVII	225 38	+ 7 +12	+ 8 +15	+13 +36	+3 +5	A gain of 2% in milk yield coincident with increased proportion of concentrates
XXI	31 217	— 9 — 9	— 9 —11	— 9 —24	—7 —9	A loss of 2% in milk yield coincident with decreased proportion of concentrates
XXV XXIV	89 50	— 6 —13	— 7 —15	— 6 —27	—3 —7	A loss of 4% in milk yield coincident with decreased proportion of concentrates

Three positive, one negative and one indeterminate result! A doubtful outcome, from which one cannot generalize with safety. Moreover, the three positive results occur in the comparisons where the protein changes are out of proportion to those of the digestible nutrients. In other words, the 2 to 4 percent coincident differences noted above may be ascribed full better to the profound modifications in the protein content of the rations than to changes in the proportions of roughages and concentrates.

In an endeavor to gain further insight into this matter, such data in Tables I-XXVI inclusive as was essential to the study now in hand was collated with care as to groupings. Plus and minus signs were disregarded. Each table was given equal value in the summaries regardless of the number of pieces of contributing data. The following table is the outcome of this attempt:

Reference number	Tables	Dry matter	Digestible dry matter	Digestible protein	Milk yield		Changes in Concentrates	Changes in Protein
A	XV,XVII,XXI,XXIV,	11	13	30	6.5	A	+greatly	+greatly
B	XVI, XVIII, XIX,	6	7	14	3.7	B	+considerably	+considerably
C	V, XII, XIII,	0	1	11	3	C	+ "	+ "
D	XXII, XXV, XXVI,	7	8	9	3.3	D	+ "	+ "
E	XX, XXIII,	10	9	8	6	E	— "	+ "
F	X, XI, XIV,	3	3	15	3	F	O	+ "
G	IX,	7	9	1	0	G	+greatly	O
H	VI, VII, VIII,	7	6	1	1	H	—somewhat	O
I	I, II, III, IV,	1	1	2	0.5	I	O	O

Condensing these data still further, the following showing is made:

Reference number	Tables	Dry matter	Digestible dry matter	Digestible protein	Milk yield	Changes in Concentrates	Changes in Protein
I	A,	11	13	30	6.5	+greatly	+greatly
	F,	3	3	15	3	O	+considerably
					3.5	percent increase.	
II	B, C, D and E,	5.8	6.3	10.5	4	considerable increases	
	F,	3	8	15	3	O	+considerably
					1.	percent increase.	
III	G and H,	7	7.5	1	0.5	some gain	no change
	I,	1	1	2	0.5	O	O
					No	change.	

In I a considerable change in the proportion of concentrate to roughage and a great change in the protein content as compared with no change in the one and a considerable change in the other is noted. The difference in milk yield was 3.5 percent.

In II a smaller change in the proportion of concentrate to roughage and a moderate change in protein as compared with no change in the one and a considerable one in the other is shown. The difference in milk yield is 1 percent in favor of the former.

In III a smaller change in the proportion of concentrate to roughage and no change in protein as compared with uniform feeding is noted. The difference in milk yield was nil.

In the first case the protein changes are doubtless factors in the outcome. In the second there is a gain in yield accompanying an increase in the proportion of concentrate to roughage and coincidently a decrease in the relative proportions of protein. In the third case, where protein changes cut no figure and but minor changes in proportions of concentrates to roughages occur, no change in yield was made.

Yet another view of this matter may be taken by comparing the essential results of a few carefully selected tables, as follows:

Reference number	Tables	Number of records	Dry matter	Digestible dry matter	Digestible protein	Carbo-hydrates	Milk yield
A	VII,	6	+9	+9	0	+10	+1
B	XXI, XIV,	85	+3	+3	+15	+2	+3
C	XV, XIX,	424	+9	+10	+23	+8	+4

If 9 percent increase in digestible dry matter in A is accompanied by 1 percent gain in milk flow; if 15 percent of increase in protein in B is accompanied by 3 percent gain in milk flow; *query*, would 10 percent increase in dry matter and 23 percent increase in protein in C be accompanied by 4 percent gain in milk flow?

Reference number	Tables	Number of records	Dry matter	Digestible dry matter	Digestible protein	Carbo-hydrates	Milk yield
X	VIII, IX,	34	—6	—6	0	—8	—1
Y	XII,	8	0	—1	—17	+2	—3
Z	XII, XIII, XXI, XXII, XXIV, XXV, XXVI,	652	—8	—9	—16	—6	—6

If 6 percent decrease in digestible dry matter in X is accompanied by 1 percent loss in milk flow; if 17 percent decrease in protein in Y is accompanied by a 3 percent loss in milk flow: *query*, would 9 percent decrease in digestible dry matter and 16 percent decrease in protein be accompanied by a 6 percent loss in milk flow, *unless the proportion of concentrate to roughage shown in Z was a factor?*

The case is not a clear one; but it is the writer's judgment that it is more likely that the proportion of digestible dry matter furnished in the form of the grain ration to that supplied as roughage was a factor influencing the flow than that it had no effect. To measure its effect as apart from that of the other factors with the data now in hand is difficult if not impossible.[1]

DIGESTIBLE PROTEIN

A main consideration in taking up this study was a desire to determine so far as might be the results arising from changes in the amounts of protein fed as well as in its amount as related to other nutrients. The proportional variations therein are considerably greater than in the case of the carbohydrates or fat.

The tables may be summarized for protein as follows:

Tables I and II. No change in rations nor in amounts or character of total or any digestible nutrient. (19 and 68 comparisons). No change in yield (+1); slight change (+2) in weight of protein eaten to product made.

Table III. No change in ration, nor in amounts or character of total or any digestible nutrient except protein, which slightly decreases.

[1]See in this connection Pa. Sta. Bul. 71 (1905).

(15 comparisons). No change in yield (—1) or in weight of protein eaten to product made (—1).

Table IV. A change in rations, but no change in amounts or character of total or any digestible nutrient except protein, which slightly increases. (85 comparisons). No change in yield (0), but 4 percent increase in weight of protein eaten to product made.

Table V. A change in rations; but no change in amounts or character of total or any digestible nutrient except protein, which decreases. (10 comparisons). Ten percent decrease in protein consumption, accompanied by 2 percent decrease in yield, and 8 percent in protein consumption proportioned to yield.

Table VI. No change in rations; increase in amounts of total and all digestible nutrients except protein, which remains unchanged. (13 comparisons). No change in yield or in protein consumption per pound of product made.

Table VII. A change in rations; increase in amounts of total and all digestible nutrients except protein, which remains unchanged. (6 comparisons). No change in yield or in protein consumption per pound of product.

Table VIII. No change in rations; decrease in amounts of total and all digestible nutrients except protein, which remains unchanged. (21 comparisons). Slight change in yield (—3); no change (+1) in protein consumption per pound of product.

Table IX. A change in rations; decrease in amounts of total and all digestible nutrients except protein, which remains unchanged. (13 comparisons). No change in yield; slight increase (+2) in protein consumption per pound of product.

Table X. No change in rations, nor in amount or character of total or any digestible nutrient except protein, which increases. (20 comparisons). No change in yield, but 9 percent increase in protein consumption per pound of product.

Table XI. A change in rations, but no change in amount or character of total or any digestible nutrient except protein, which greatly increases. (20 comparisons). Twenty-three percent increase in protein consumption, accompanied by 4 percent gain in yield, and 23 percent in protein consumption per pound of product.

Table XII. No change in rations nor in amount or character of total or any digestible nutrient except protein, which decreases. (11 comparisons). Seven percent decrease in protein consumption, accompanied by slight loss in yield and in protein consumption per pound of product (—3).

Table XIII. A change in rations, but no change in amount or character of total or any digestible nutrient except protein, which greatly decreases. (8 comparisons). Seventeen percent decrease in protein consumption, accompanied by 3 percent loss in yield, and 16 percent in protein consumption per pound of product.

Table XIV. No change in rations, but total and all digestible nutrients increased. (45 comparisons). Fifteen percent increase in protein consumption, accompanied by 4 percent gain in yield and 11 percent in protein consumption per pound of product.

Table XV. A change in rations; total and all digestible nutrients increased. (143 comparisons). Thirty-four percent increase in protein consumption, accompanied by 6 percent gain in yield and 25 percent in protein consumption per pound of product.

Table XVI. A change in rations; total and all digestible nutrients increased; digestible nutrients less than 15.5 pounds. (18 comparisons). Eighteen percent increase in protein eating, accompanied by 4 percent gain in yield and 14 percent increase in consumption per pound of product.

Table XVII. A change in rations; total and all digestible nutrients increased from less to more than 15.5 pounds. (38 comparisons). Thirty-six percent increase in protein eating, accompanied by 6 percent gain in yield and 26 percent increase in consumption per pound of product.

Table XVIII. No change in rations; total and all digestible nutrients increased; digestible nutrients more than 15.5 pounds. (52 comparisons). Nine percent increase in protein eating, accompanied by 2 percent gain in yield and 7 percent increase in consumption per pound of product.

Table XIX. A change in rations; total and all digestible nutrients increased; digestible nutrients more than 15.5 pounds. (173 comparisons. Sixteen percent increase in protein eating, accompanied by 4 percent gain in yield and 12 percent increase in consumption per pound of product.

Table XX. No change in rations; total and all digestible nutrients decreased. (70 comparisons). Nine percent decrease in protein eating, accompanied by 5 percent loss in yield and 2 percent decrease in protein consumption per pound of product.

Table XXI. A change in rations; total and all digestible nutrients decreased. (217 comparisons). Twenty-four percent decrease in protein eating, accompanied by 8 percent loss in yield and 18 percent decrease in protein consumption per pound of product.

Table XXII. A change in rations; total and all digestible nutrients decreased; digestible nutrients less than 15.5 pounds. (22 comparisons). Ten percent decrease in protein eating, accompanied by 6 percent loss in yield and 4 percent decrease in protein consumption per pound of product.

Table XXIII. No change in rations; total and all digestible nutrients decreased; digestible nutrients decreased from more than to less than 15.5 pounds. (9 comparisons). Seven percent decrease in protein eating, accompanied by 7 percent loss in yield, but no change in protein consumption per pound of product.

Table XXIV. A change in rations; total and all digestible nutrients decreased; digestible nutrients decreased from more than to less than 15.5 pounds. (50 comparisons). Twenty-seven percent decrease in protein eating, accompanied by 8 percent loss in yield and 22 percent decrease in protein consumption per pound of product.

Table XXV. No change in rations; total and all digestible nutrients decreased; digestible nutrients more than 15.5 pounds. (89 comparisons). Six percent decrease in protein eating, accompanied by 3 percent loss in yield and 2 percent decrease in protein consumption per pound of product.

Table XXVI. A change in rations; total and all digestible nutrients decreased; digestible nutrients more than 15.5 pounds. (255 comparisons). Ten percent decrease in protein eating, accompanied by 4 percent loss in yield and 10 percent decrease in protein consumption per pound of product.

Table XXVII. A change in rations; total and all digestible nutrients but protein increased; protein decreased. (29 comparisons). Sixteen percent decrease in protein eating, no change in yield, and 15 percent decrease in protein consumption per pound of product.

Table XXVIII. No change in rations; total and all digestible nutrients but protein decreased; protein increased. (8 comparisons). Eight percent increase in protein eating, accompanied by no change in yield, but by 8 percent increase in protein consumption per pound of product.

Table XXIX. A change in rations; total and all digestible nutrients but protein decreased; protein increased. (63 comparisons). Twenty-one percent increase in protein eating, no change in yield, but 23 percent increase in protein consumption per pound of product.

DIGESTIBLE CARBOHYDRATES

The matter contained in the first paragraph concerning digestible dry matter which appears on page 363 might well be repeated here with entire safety, word for word. There were, naturally, very few vari-

ations within any one table in the percentage figures for total dry matter, for digestible dry matter and for digestible carbohydrates. In but a single case is there a variation amounting to 4 percent, and such divergencies as do exist are of a nature to emphasize rather than minimize the statements already made, which in other words tend for this purpose to be understatements rather than the reverse.

CALORIES

The statement as to carbohydrates holds for the calories as well as for the carbohydrates.

COST

The cost of the rations was calculated from assumed prices for hay and silage ($10 and $3 respectively) and market prices for grain feeds. It is well understood that cost and food value show no necessary parallelism. It is this fact which in part explains some of the apparent anomalies in the tabular matter and in the subjoined statements as to the relationship of cost and nutrient supply. The following points, however, seem fairly clear:

1. When similar amounts of nutrients were fed the cost of the ration was essentially unaltered (I-IV).

2. When the supply of nutrients was somewhat increased—protein but slightly—the cost was unaltered (XVIII); when increased—protein being most affected—the cost was somewhat advanced (XIV, XVI, XIX); when considerably increased—and protein greatly so—the cost was considerably enhanced (XV, XVII).

3. When the supply of nutrients was somewhat decreased—protein but slightly—the cost was essentially unaltered (XX, XXII, XXIII, XXV, XXVI); when considerably decreased—and protein greatly so—the cost was somewhat lessened (XXI, XXIV).

4. When the supply of nutrients was unchanged, other than protein which increased, there was a slight increase in cost (X, XI); when it remained the same, save protein which decreased, there was a sharp fall in cost in two cases (V, XIII) and a gain in one (XII) in which the protein shortage was but slight.

5. When all nutrients but protein increased, so did cost (VI, VII); when all but protein decreased, cost remained stationary or advanced (VIII, IX); when all nutrients increased but protein, which decreased, or *vice versa*, cost fluctuations were but slight (XXVII-XXIX).

6. Speaking broadly, the more was fed the more the ration cost and *vice versa*, regardless of the quality of the ration, i. e. its protein content. Yet this often plays an important part. When the protein

plus or minus is 10 percent or more there is a larger proportion of sizable variations in cost than when they are less than 10 percent.

GENERALIZATIONS

Leaving now the specific statements and attempting to generalize, one may hazard the following statements based on the tabular matter:

1. The testimony afforded by the results as between different rations and the same ration fed in different amounts is so nearly alike, speaking broadly, that one may safely group them together and argue on the basis of variations in dry matter or in nutrient consumption regardless of their origin.

2. When like quantities of the several nutrients were eaten, production was unaltered.

3. A 6 percent increase or decrease in total dry matter eaten was accompanied by a corresponding 2 percent change in yield; a 10 percent increase or decrease, by a 5 percent change in yield.

The greater the increase or decrease in dry matter consumption the greater the gain or loss in yield, which seemed, however, retarded or augmented somewhat by the protein content of the ration; that is to say, when the protein supply was inordinately or disproportionately raised or lowered as compared with that of the other nutrients, the gain or loss in yield was still further modified in the same direction to the extent on the average of 2 percent as compared with similar gains or losses when all the nutrients were proportionately raised or lowered. This statement may be still further reduced to a less exact but perhaps clearer one, as follows: The milk flow raised and sunk with more or less feed, raising a bit higher and shrinking a bit more if the protein supply was relatively liberal on the one hand or scant on the other.

4. A 7 percent increase or decrease in digestible dry matter eaten was accompanied by a 3 percent change in yield; a 12 percent increase or decrease, by a 6 percent change in yield; or, in other words, as food varied so did the yield, but to a less degree. When the larger proportions of the digestible dry matter were derived from the grain rations on the one side of the comparison than on the other, there appeared to be a tendency towards a somewhat larger production as a result of such increase. The outcome in this respect is not clear-cut, being complicated by the generally coincident modifications in the protein content of the rations.

5. As for digestible dry matter, so for digestible carbohydrates and for calories, word for word and, essentially, figure for figure.

6. A 3 percent increase or decrease in digestible protein eaten had no effect on production; a 7 percent increase or decrease was ac-

companied by a 2 to 3 percent change in yield; and a 22 percent increase or decrease by a 4 to 5 percent change.

When the protein content of the ration was lowered, and other nutrients were eaten in like quantity, yield and cost fell (V, XII, XIII); when it alone among the nutrients was not increased in quantity, there was no loss in yield and cost increased (VI, VII); when it alone was lowered in quantity and all the other nutrients increased, there was no loss in yield or change in cost (XXVII).

When all the nutrients were lessened proportionately in amount, yield fell, but cost was irregularly affected (XX, XXII, XXIII, XXV, XXVI).

When all nutrients were lessened in amount, protein proportionately most of all, yield fell decidedly and cost likewise lowered (XXI, XXIV).

When the protein content of the ration was raised and other nutrients were eaten in like quantity, yield and cost increased very slightly (X, XI); when it alone among the nutrients was not decreased in quantity, little or no loss in yield occurred, and slight increase in cost ensued (VIII, IX).

When it alone was increased in quantity and all other nutrients decreased, there was no gain in yield and but slight gain in cost (XXVIII, XXIX).

When all the nutrients were increased proportionately in amount, there was a slight gain in yield and no change in cost (XVIII).

When all nutrients were increased in amount, protein proportionately most of all, there were large gains in both yield and cost (XIV-XVII, XIX).

When increased from less than to somewhat more than 2 pounds daily the gain in yield approximated 5 percent, and in cost 3 percent (XVI, XVII); and when it shrank from rather more than to rather less than 2 pounds the loss in yield approximated 4 percent, and in cost 5 percent (V, XXII).

When increased from 2 to 2.5 pounds the gain in yield approximated 4 percent, and in cost 2 percent (XI); and when it shrank from 2.5 to 2 pounds the loss in yield reached 6 percent, and in cost 9 percent (XIII, XXIV).

When increased from 2.25 and 2.5 to nearly 3 pounds, the gain in yield approximated 5 percent, and in cost 4 percent (XIV, XV, XIX); and when it shrank from 3 to 2.25 pounds the loss in yield reached 8 percent, and in cost 3 percent (XXI).

7. A change in feeding of from more than to less than 15.5 pounds of digestible nutrients or *vice versa* caused more decided changes in

yield than did modifications in feeding on either side of that line, the average figures being 7 percent and 4 percent.

8. The nutritive ratio changes were evidenced in production fluctuations much as were those of digestible protein; when it narrowed, production generally increased, and *vice versa.*

9. The ultimate effect of a given food supply upon the milk flow is doubtless the more or less composite result of several coincidently active factors, including, primarily, changes in the amounts of digestible nutrients taken as a whole; secondarily, changes in the amounts of digestible protein, and, probably, modifications in the proportions of digestible nutrients consumed in concentrates and in roughage.

The writer's study of these data lead him to the conclusion that as a whole they do not support the doctrine which lays extreme stress on the paramountcy of protein; that they indicate that a ration with a nutritive ratio wider than 1:6, perhaps as wide as 1:7, or, indeed, in some cases one slightly wider, may prove economically as effective as the traditional 1:5.4; that a sufficiency of nutrients, affording enough available energy for bodily needs, if carrying a fair amount of digestible protein, not necessarily as much as 2.5 pounds, may prove economically as serviceable as does a richer ration.

What are the views of others?

Jordan[1] says that "the evidence presented concerning one point is fairly consistent and is important, viz.: that changes in the quantity of nutrients have greatly more influence on the milk yield than proportionately large changes in the amount of protein. These data offer strong evidence that if the available energy of the ration is sufficient and is kept at a uniform point, there may be quite a wide range in the nutritive ratio without materially affecting the milk flow."

Haecker[2] maintains that 2 or less pounds of digestible protein daily, derived from home-grown materials, serve equally as well as larger amounts derived in part from purchased byproducts.

Beach[3] states that "rations containing more (digestible) protein than those commonly fed[4] to dairy cows are more economical," particularly "when the original rations carried less than 1.5 pounds of (digestible) protein," but lays "great emphasis . . . . upon the additional value of manure obtainable from the more nitrogenous rations."

The writer acknowledges his obligations to Prof. C. L. Beach of the Connecticut (Storrs) station, who kindly reviewed the manuscript and made pertinent and helpful suggestions to the adoption of which much of what little value may attach to this article may justly be ascribed.

[1]Introduction, Wheeler's article, N. Y. (State) Sta. Rpt. 20, p. 62 (1901).
[2]Minn. Sta. Bul. 71 (1901).
[3]Conn. (Storrs) Sta. Bul. 34 (1905).
[4]1.75 pounds in the 41 herds which were under observation. The average recommended amount of increased digestible protein was 0.60 pounds, making the average amount 2.35 pounds.

FEEDING TRIALS WITH COWS

JOSEPH L. HILLS

This article is summarized at its close, on page 404. The results of the trials are concisely stated therein and cross references given.

I. INTRODUCTION

The large size of the station herd admits of much work being done in feeding experimentation, a wide range in choice of animals, much repetition, and the conduct at one time of a relatively large number of trials. For several years a dual purpose has been held in mind in the plan and execution of these trials, viz.: to add not only to our knowledge as to the relative values of sundry roughages and concentrates but also to test the trustworthiness of the methods used; and it is expected to pursue this line of work for some time in the future.

The experimental feeding of the winter of 1904-05 was directed at the determination of:

1. The feeding value of India wheat meal.
2. The feeding value of hominy feed.
3. The feeding value of cottonseed meal.
4. The feeding value of linseed meal.
5. The extent of experimental error.

The records made by 42 cows during the six months' feeding trials are deemed safe to use as a basis for deductions. But little sickness interfered. The results in but a very few cases were impaired because of temporary illness, of early drying off, or because the animal went off feed. The herd has never gone through a winter's trial in better shape or with less disturbance. No serious disturbing factor common to the entire herd was noted.

The 42 cows whose records are available for use were distributed among the several tests as follows:

(a)	India wheat vs. wheat bran	5
(b)	India wheat vs. cottonseed and linseed meals	6
(c)	Hominy feed vs. wheat bran	6
(d)	Hominy feed vs. cottonseed and linseed meals	5
(e)	Cottonseed vs. linseed meals	20[1]
		42

All the cows were not equally suited to the purpose as regards time of lactation, although in this respect the herd was never in so

[1]The records of seven of these cows are available in each of the tests labelled a, b, c and d.

good a condition for experimental feeding work. Yet, notwithstanding, a careful study of previous records—extending over nearly ten years with some animals—of ages, times of calving, flow and quality of milk, times of service, etc., was made in connection with selection for the sundry trials.

DETAILS OF FEEDING

The general plan of the trials was the same as that hitherto in vogue at this Station and is outlined on pages 212-213 of the sixteenth report. The changes in daily grain feed were as follows:

(a) *India wheat vs. wheat bran;* three cows fed Nos. 1 and 2 alternately, two cows fed No. 2 continuously.

(b) *India wheat vs. cottonseed and linseed meals;* four cows fed Nos. 1 and 3 alternately, two cows fed No. 3 continuously.

(c) *Hominy feed vs. wheat bran;* four cows fed Nos. 1 and 4 alternately, two cows fed No. 4 continuously.

(d) *Hominy feed vs. cottonseed meal;* three cows fed Nos. 1 and 5 alternately, two cows fed No. 5 continuously.

(e) *Cottonseed vs. linseed meals;* three cows fed Nos. 1 and 6, three Nos. 1 and 7, and three Nos. 6 and 7 alternately; seven cows fed No. 1, two No. 6, and two No. 7 continuously.

(f) The sundry cows (19 in number) fed continuously on any one of the several rations, furnished data of service in the determination of the extent of *experimental error.*

The heifers were fed 6 pounds of grain daily, the other cows, 8 pounds daily, unless otherwise stated.

WEIGHTS OF COWS

The cows were weighed daily on the first three days at the opening period and on the last three days of each period. Speaking broadly, three-fourths of the cows gained in weight, one-sixth came through the winter with less than 15 pounds difference between their Christmas and Decoration day live weights, while only two lost more than 15 pounds. The average gain in live weight in April and May over the December-January condition was 31 pounds. A careful study of the data shows no decided advantage of one ration over another in this respect. A general tendency towards heavier weights as the trials advanced is a trend which prolonged feeding in winter and spring has always shown, one which is quite natural and is always to be expected.

BARN TEMPERATURES

The cows were stabled in two portions of the barn structure, the temperatures of which were taken daily at 5 A. M., 12 M., and 6 P. M. Its exposed location caused considerable fluctuation in the temperature of the cow stables during the winter, notwithstanding the many animals housed therein. The average temperatures, morning, noon and night, during each period, the range of variations, and the percent of the entire number of observations within 3° F. of the mean of each period are tabulated in the appendix. The winter was a cold one, but was not characterized by as many or as severe cold spells as its immediate predecessor. The barns averaged 2° F. warmer during the winter months, 4° warmer in April, and 3° cooler in May than in 1903-04. It was, however, 4° cooler during the first three periods than it was during the winter of 1902-03. The only time the barns showed a low temperature for a considerable space was on January 24-27, when they ranged from 36° to 47°, with an average of 42°, or 6° F. below the normal for the period. Yet 56 cows gave during the five days preceding the cold spell, during the four days it lasted, and during the four days succeeding it, daily averages of 918, 911 and 903 pounds of milk, which is only the normal shrinkage under uniform conditions. It may be assumed with safety that such temperature fluctuations as occurred had no appreciable effect on the outcome of the trials. At any rate, a close study of this matter for over ten years has never disclosed any weather effects so marked as to raise a presumption that material error was thus introduced. A more uniform temperature, if attainable, would be desirable, but is not essential.

DATES OF FEEDING PERIODS

I	Preliminary, Dec. 3—15. Experimental, Dec. 15—Jan. 7.	IV	Preliminary, March 18—30. Experimental, March 30—April 22.
II	Preliminary, Jan. 7—19. Experimental, Jan. 19—Feb. 11.	V	Preliminary, April 22—May 4. Experimental, May 4—27.
III	Preliminary, Feb. 11—23. Experimental, Feb. 23—March 18.		

The following tables show the periods, dates, cows, and the nature and analyses of the grain feeds used. The arabic numerals in the columns headed I to V refer to the feed mixtures, which were made up by weight of:

No. 1. Wheat bran, 4 parts; cottonseed meal, 1 part; linseed meal, 1 part.

No. 2. Wheat bran, 4 parts; india wheat, 2 parts.

No. 3. Wheat bran, 2 parts; cottonseed meal, 1 part; linseed meal, 1 part; india wheat, 2 parts.

No. 4. Wheat bran, 4 parts; hominy feed, 2 parts.

No. 5. Wheat bran, 2 parts; cottonseed meal, 1 part; linseed meal, 1 part; hominy feed, 2 parts.

No. 6. Wheat bran, 2 parts; cottonseed meal, 1 part.

No. 7. Wheat bran, 2 parts; linseed meal, 1 part.

COWS USED AND NATURE OF GRAIN RATIONS, ETC., FED DURING EACH PERIOD

Name	Approximate age Nov. 1, 1904	Calved 1904 or 1905	Served 1904 or 1905	Period numbers* and feeds† eaten				
				I	II	III	IV	V
Elizabeth,	4	Nov. 13,	Feb. 16,	1	2	1	2	1
Inez,	12	Dec. 23,	June 4,	..	1	2	1	2
Hallowe'en,	11	Dec. 24, '03,	Aug. 7	2	1	2	..	..
Eva,	12	Nov. 23,	....	2	2	2	2	2
Fresno,	6	Dec. 29,	Feb. 26,	..	2	2	2	2
Zirconia,	8	Oct. 4,	June 20,	1	3	1	3	1
Santa Clara,	6	Dec. 14,	March 25,	..	1	3	1	3
Edith,	7	April 28,	Oct. 2,	1	3	1	3	1
Sonoma,	6	Jan. 13,	July 31, '04,	3	1	3	..	..
Zeta,	7	Sept. 25,	June 20,	3	3	3	3	3
Vt. Una,	5	Oct. 31,	Jan. 23,	3	3	3	3	3
Stephanie,	8	Aug. 21,	April 13,	1	4	1	4	1
Yttria,	8	Sept. 22,	....	4	1	4	1	4
Epsilon,	4	....	May 26,	1	4	1	4	1
Lady Perusia,	11	Feb. 15,	May 24,	4	1	4	1	4
Santa Rosa,	6	Nov. 7,	Jan. 11,	4	4	4	4	4
Rebecca,	8	Sept. 19,	....	4	4	4	4	4
Chi,	9	....	April 23,	1	5	1	5	1
Lucerne,	11	Nov. 2,	June 27,	5	1	5	1	5
Fatima,	3	Sept. 4,	Jan. 30,	1	5	1	5	1
Sarnia,	6	Sept. 20,	Jan. 18,	5	5	5	5	5
Ursula,	9	Oct. 30,	June 26,	5	5	5	5	5
Constance,	5	Aug. 10,	Nov. 13,	1	6	1	6	1
Elsa,	8	Nov. 11,	....	6	1	6	1	6
Gamma,	7	Sept. 11,	Jan. 26,	1	6	1	6	1
Lavender,	7	Sept. 10,	March 8,	1	1	1	1	1
Vivian,	9	Nov. 12,	June 5,	1	1	1	1	1
Laura,	6	Sept. 16,	March 16,	6	6	6	6	6
Cassandra,	5	....	March 17,	1	1	1	1	1
Alta,	8	Aug. 7,	Dec. 26,	1	7	1	7	1
Adelaide,	11	Sept. 29,	....	7	1	7	1	7
Star Bright,	8	Aug. 24,	April 24,	1	7	1	7	1
Yemassee,	10	Sept. 17,	Dec. 8,	1	1	1	1	1
Mu,	5	Sept. 18,	June 10,	1	1	1	1	1
Mermaid,	9	Aug. 16,	Dec. 1,	1	1	1	1	1
Rosel,	8	Sept. 2,	Dec. 9,	1	1	1	1	1
Janice,	9	Aug. 18,	Feb. 16,	7	7	7	7	7
Judith,	8	April 25,	Nov. 12,	6	7	6	7	6
Yuba,	6	Nov. 28,	May 8,	7	6	7	6	7
Zillah,	4	Aug. 3,	Jan. 20,	7	6	7	6	7
Pomona,	13	Dec. 22, '03,	Oct. 30,	6	6	6	6	6
Myrtle,	4	Oct. 6,	Jan. 1,	7	7	7	7	7

*In roman I-V. †In arabic 1-7.

AVERAGE ANALYSES OF FODDERS AND FEEDS

Fodders and feeds	Original substance		Composition of dry matter							
	Water	Dry matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
Hay (main barn),	15.31	84.69	7.53	9.66	30.99	49.20	2.62	1.54	0.55	1.57
Hay (annex barn),	14.17	85.83	7.07	9.19	33.66	47.75	2.33	1.47	0.51	2.23
Barn grass hay,	22.63	77.37	15.53	11.31	36.53	35.44	1.19	1.81	0.59	6.09
Oat hay,	16.76	83.24	10.90	10.81	34.33	41.79	2.17	1.73	0.78	3.96
Corn silage (immature),	80.28	19.71	6.95	9.86	27.68	53.56	1.95	1.58	0.62	1.70
Mixed feed, No. 1,	11.23	88.77	6.52	23.81	10.36	52.60	6.70	3.81	2.62	1.62
No. 2,	13.04	86.96	5.84	15.10	7.26	67.20	4.60	2.42	2.27	1.35
No. 3,	12.58	87.42	5.70	22.16	7.81	58.19	6.14	3.55	1.92	1.36
No. 4,	11.90	88.10	5.72	14.31	8.41	65.62	5.82	2.30	2.32	1.35
No. 5,	11.79	88.21	5.60	22.13	8.06	56.70	7.51	3.54	1.97	1.39
No. 6,	11.73	88.71	6.95	24.19	11.04	50.58	7.24	3.87	2.82	1.85
No. 7,	11.53	88.47	6.58	23.12	10.49	54.05	5.76	3.70	2.19	1.69
Wheat bran,	11.94	88.06	6.80	15.32	10.22	62.75	4.91	2.45	2.94	1.68
Cottonseed meal,	9.03	90.97	6.82	42.56	10.93	28.63	11.06	6.81	2.50	1.97
Linseed meal,	10.92	89.08	6.10	35.63	9.46	41.21	7.60	5.70	1.70	1.36
India wheat meal,	15.41	84.59	4.07	13.90	1.57	77.70	2.76	2.23	0.85	0.50
Hominy feed,	11.08	88.92	2.48	11.47	3.66	75.62	6.77	1.84	0.99	1.99

AVERAGE DIGESTIBLE INGREDIENTS IN FODDERS AND FEEDS

Fodders and feeds	Dry matter	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nutritive ratio, 1:
Hay (main barn),	50.8	4.7	15.2	26.7	1.3	9.7
Hay (annex barn),	51.5	4.5	16.8	26.2	1.2	10.2
Barn grass hay,	37.9	4.7	12.4	14.3	0.6	6.0
Oat hay,	40.8	4.9	12.6	18.1	1.1	6.8
Immature corn silage,	13.0	1.0	3.8	7.1	0.3	11.7
Mixed feed No. 1,	59.5	17.6	3.6	33.2	4.7	2.7
No. 2,	56.6	10.3	1.7	40.3	2.8	4.7
No. 3,	61.2	16.3	2.5	35.1	4.5	3.0
No. 4,	62.6	9.9	2.8	45.7	3.9	5.8
No. 5,	67.1	16.4	3.4	40.5	5.5	3.5
No. 6,	58.6	18.1	3.8	30.1	5.2	2.5
No. 7,	60.2	17.2	3.6	34.0	4.0	2.7
Wheat bran,	54.6	10.5	2.7	38.2	3.0	4.5
Cottonseed meal,	67.3	34.1	5.6	15.9	9.4	1.3
Linseed meal,	70.4	28.3	4.8	28.6	6.1	1.7
India wheat meal,	59.2	9.1	...	44.7	1.9	5.4
Hominy feed,	80.1	7.9	2.7	63.9	4.9	9.9

Experimental feeding work began December 3 and closed May 27. Every milking of each cow was weighed and sampled. Nine milking composites were analyzed for total solids and fat, using the Babcock, lactometer and the Richmond slide rule. The system in use as to sampling fodders and feeds, and as to control of the quality of hay fed was the same as that hitherto in use and outlined on pages 215-216 of the sixteenth report.

The hay was in general a fair grade of early cut hay of mixed grasses, largely timothy, with much lighter sprinkling of clover than usual. Oat hay, however, was necessarily fed to some extent during the first two periods, while to a few animals more or less barn grass hay was fed during the first period. The silage was made of immature Sanford corn, was fairly well kept and somewhat acid. Its quality and feeding value were impaired by immaturity. The grain feeds were with one exception standard materials of standard quality, although the bran was of a lower grade than was desirable.

The statements as to the volume of work, the multiplicity of samples, the considerable extent of the data involved in these trials, methods in vogue for checking mathematical accuracy, etc., given on pages 216-217 of the sixteenth report, are equally pertinent here. The condensed data as usual appears in the appendix.[1] This is omitted in the general edition, since it comprises a mass of figures of interest solely to the student of animal husbandry and as a matter of record showing the basis for the conclusions drawn from these trials. Copies may be obtained on application by such parties as may desire it. It is printed in the edition sent to the experiment station and library mailing lists. Only such tabular matter as is needed to explain the text is included in the body of the articles.

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[1]APPENDIX CONTAINING CONDENSED DATA PERTAINING TO ARTICLES ON FEEDING TRIALS WITH COWS, PAGE 428 AND SEQ.

I. Weights of cows.
II. Average barn temperatures, with ranges and percentages of uniformity.
III. Analyses and digestible ingredients in fodders and feeds; (*a*) analyses on dry basis; (*b*) digestion coefficients; (*c*) pounds of digestible nutrients in 100 pounds of original substance.
IV. Feeding records of the individual cows in feeding tests.
V. Production records; showing production and same per unit for each individual cow in feeding tests.
VI. Difference tables. (*a*) Totals of differences; (*b*) Percentage differences.
VII. Results of experimental feeding on different rations.

II. THE FEEDING VALUE OF INDIA WHEAT MEAL[1]

The last report (pages 491-498) detailed a feeding trial of this home-grown concentrate, being the only one which thus far has come to the writer's attention. The outcome was more favorable to the india wheat than was to be expected, judging solely by its analysis. It seemed worth while, therefore, to repeat the observation; especially as such repetitions are in line with the Station's regular policy. The trials paralleled those of last year, comparing it with wheat bran and with cottonseed and linseed meals. The meal averaged about 2 percent richer in protein than the whole buckwheat or than cornmeal, and 5 percent richer than buckwheat flour. It carried considerably less nitrogen-free extract matter than either buckwheat flour or cornmeal. It is obviously not adapted to narrowing a ration. It was freely eaten without any observed ill-effects, two and two-thirds pounds daily being fed in combination with bran (as feed No. 2), or with bran, cottonseed and linseed meals (as feed No. 3).

1. COMPARED WITH WHEAT BRAN

Six mature cows were used in the trial with wheat bran, four fresh and two far along in milk. Four of these were fed mixed feeds 1 and 3 in alternation, while two were fed continuously with No. 3. The records of seven cows fed No. 1 are also available.

COMPARISON WITH STANDARDS

Wolff.—Three of the six cows ate plenty and to spare, two barely ate standard amounts of nitrogen-free extract matter, while Sonoma, a heavier cow than the average and approaching calving, did not eat standard amounts of the sundry nutrients.

Wolff-Lehmann.—All but Santa Clara, an 800-pound cow yielding from 25 to 30 pounds of milk daily, ate standard or superstandard amounts of the sundry nutrients. Santa Clara was shy only in protein eating. Una alone of this lot ate enough total dry matter to satisfy the inordinate demands (in this particular) of this standard. In fact only nine of the forty-two cows used in these trials did eat enough total dry matter, according to this standard, which is in this respect usually impracticable if not impossible to meet.

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[1]India or Tartary wheat (*Fagopyrum Tartaricum*) is a plant of the buckwheat family, which differs from the common buckwheat (*F. esculentum*) in having the grains smaller, dull-roughish, with angles wavy and less acute: It is grown to quite an extent in Vermont hill towns, and its seed when ground is commonly used there like the common buckwheat flour for human food and also as a cattle food. It rarely enters into trade as a cattle feed, being simply a home-grown concentrate. Its use seems to be lessening, but it still cuts quite a figure in the feeding practice on many farms back from the railroads and out of easy access to the byproducts now so widely offered."—Vt. Sta. Rpt., 17, p. 491 (1905).

RESULTS

The system inaugurated last year,[1] whereby there is used in the text only the simpler data derived from a single method of calculation, provided the results thereof seem valid, will be followed in this article, the "difference figures" being footnoted.[2] Whenever for any reason the testimony afforded by the other methods of calculation suggest doubt, they are qualified by footnote reference. This procedure conduces to the intelligibility of the tabulated matter, to the tangibility of the general results, and does not seem to impair the accuracy of the deductions.

Following this procedure recourse is had in the following table to data in the appendix in order to determine the relative worth of the two rations now under survey. The result of this trial seems fairly measured by the data presented in Table VII in the appendix. These indicate that when grain feeds Nos. 1 and 3 were fed, each for 207 days, with hay and silage as roughages, there were:

	No. 1 ration	No. 3 ration	Percentage gain or loss when No. 3 was fed[3]
Pounds of dry matter eaten,	4,531	4,521	0
Pounds of milk made,	3,798	3,815	0
Percent total solids,	14.73	14.74	0
Pounds of fat,	4.34	4.33	0
Pounds of total solids made,	558.5	562.0	+1
Pounds of fat made,	196.5	196.2	0

This trial further shows that there were made to the 100 pounds of dry matter eaten:

	No. 1 ration	No. 3 ration	Percentage gain or loss when No. 3 was fed[3]
Pounds of milk,	83.9	84.3	0
Pounds of total solids,	12.3	12.4	+1
Pounds of fat	4.34	4.33	0
Ratio of fat to solids-not-fat; 1:	1.84	1.86	+1

[1]Vt. Sta. Rpt., 17, pp. 472-473 (1904).

[2]The following excerpt from the last report is pertinent here: "The tabular summaries [are] of a uniform character, the voluminous data being placed in an appendix, and the concrete results alone displayed in the text. These concrete results [are] termed 'difference figures.' It is obvious that when measuring the relative values of rations A and B it is immaterial how much milk is made when A is fed or how much when B is eaten, but that it is highly important to determine how much more is made on one ration than on the other. This excess, expressed as a percentage, is a 'difference figure.' These difference figures in the form of whole numbers, prefaced by their appropriate plus or minus signs, [are] the basis for conclusions as to the general result. The deductions [are not] based on the results of a single method of calculation or of experimentation. Two systems of measurements [are] used, both of which are discussed in full as to their nature and validity in the article entitled 'A Comparison of Feeding Trial Methods' later in this volume. Moreover, the results attained by one of these systems [are] calculated in two different ways the more certainly to detect error, and because one of these methods of calculation is apt under some circumstances to afford a somewhat erroneous result. (See end of explanatory note to Table VII in appendix)."

[3]See footnote 1 on page 385.

It was said at this point in the discussion of last year's trial that "a closer outcome could not have been looked for on uniform feeding," words which are likewise clearly applicable to the results of this year's test. The footnoted data indicate that such very minor differences, averaging 2 percent, as were developed by the calculations by the other methods tended to favor the bran as against india wheat.

2. COMPARISON WITH COTTONSEED AND LINSEED MEALS

Five fresh cows, four mature and one a four-year-old, were used. Three were fed Nos. 1 and 2 in alternation; two, No. 2 continuously, while seven others were fed No. 1 and contribute to all of the test where this feed was used. No. 1 carried wheat bran, cottonseed and linseed meals, and No. 2 the india wheat in lieu of the two latter named feeds.

COMPARISON WITH STANDARDS

Wolff.—All the cows when fed the No. 2 ration, one-third of which was india wheat, ate too little protein. Hallowe'en, far along in lactation, ate too little of all the nutrients, whether fed No. 1 or No. 2. Otherwise the food consumption of each cow was always standard or superstandard.

Wolff-Lehmann.—Inez, when eating No. 2, as well as Eva and Fresno, who always received No. 2, ate too little protein. Fresno ate far too little of all the nutrients, being at the time a heavy milker. Otherwise plenty and to spare was consumed by these and the other cows, save, of course, of total dry matter.

[1] COMPARISON OF DIFFERENCE FIGURES (SEE NOTE TO TABLE VII APPENDIX, AS WELL AS FOOTNOTE, PAGE 384)

	Total dry matter eaten	Dry matter in experimental feed	Quantity of milk	Total solids, percent	Fat, percent	Quantity of total solids	Quantity of fat	Products per 100 pounds of dry matter: In entire ration: Milk	Total solids	Fat	In experimental feed: Milk	Total solids	Fat
Table VII,	0	—2	0	0	—1	+1	0	0	+1	0	+3	+3	+2
Alternation,	+1	—3	—2	+1	0	—2	—2	—3	—2	—2	+2	+2	—1
Contin.-altern.,	+1	—2	—1	0	—2	—2	—4	—3	—3	—4	0	0	—2

[1]These data are arrived at in the following manner: As the text shows, there were 4,531 pounds of dry matter eaten when the No. 1 ration was fed, and 4,521 when the No. 3 was used. 4,531—4,521=10. 10÷4,531=0. The 10 pounds is 0 percent of 4,531 pounds, or, in other words, there was 0 percent shrinkage (0) in the food consumption. This figure (0) is a "difference figure," and it appears at the left of the first line of the above table. The other figures in the first horizontal lines are similarly obtained. In the second line, however, the figures, while similarly obtained, are derived as a result of another method of calculation, which, as explained in the footnote and at length in the note following Table VII in the appendix, sometimes gives more reliable results; and, finally, those in the third line are arrived at in yet another manner, using different cows, as explained in the article on "Comparison of Feeding Trial Methods" further along in this volume.

RESULTS

The outcome of these trials is displayed in the data given below, drawn from Table VII in the appendix, which is amply confirmed by that obtained by the other methods of caluculation or of experimentation.[1] These indicate that when two and two-thirds pounds india wheat meal is substituted in an 8 pound daily grain ration for an equal amount of half cottonseed and half linseed meals,—hay and silage as roughages and twice as much bran as the main concentrate being fed—there were during 138 days on each ration:

	No. 1 ration	No. 2 ration	Percentage gain or loss when No. 2 was fed[1]
Pounds of dry matter eaten,	2,999	2,984	—1
Pounds of milk made,	2,285	2,166	—5
Percent of total solids,	15.45	15.47	0
Percent of fat,	5.79	5.81	0
Pounds of total solids made,	349.7	333.8	—5
Pounds of fat made,	130.1	123.5	—5

This trial further shows that there were made to the 100 pounds of dry matter eaten:

	No. 1 ration	No. 2 ration	Percentage gain or loss when No. 2 was fed[1]
Pounds of milk,	75.7	72.0	—5
Pounds of total solids,	11.6	11.0	—5
Pounds of fat,	4.31	4.12	—4
Ratio of fat to solids-not-fat; 1:	1.67	1.66	—1

When the india wheat meal was substituted for the byproducts of the oil mills, there were made:

1. Five percent less milk, solids, fat and butter.
2. As rich milk.
3. Five percent less products per unit of dry matter eaten.

[1] COMPARISON OF DIFFERENCE FIGURES (SEE NOTE TO TABLE VII APPENDIX, AS WELL AS FOOTNOTE, PAGE 384)

	Total dry matter eaten	Dry matter eaten in concentrates	Quantity of milk	Total solids, percent	Fat, percent	Quantity of total solids	Quantity of fat	Products per 100 pounds of dry matter					
								In entire ration			In experimental feed		
								Milk	Total solids	Fat	Milk	Total solids	Fat
Table VII,	—1	—2	—5	0	0	—5	—5	—5	—5	—4	—3	—3	—3
Alternation,	+2	—2	—6	0	+1	—6	—5	—6	—6	—5	—4	—3	—3
Contin.-altern.,	—2	—2	—9	+2	+5	—8	—4	—9	—6	—3	—7	—4	—2

In last year's trials the cottonseed-linseed ration came out 2 percent ahead; in this year's, 5 percent. It is safe to say that it is somewhat the better of the two.

3. FINANCIAL CONSIDERATIONS

The discussion thus far has been directed solely to considerations of the effect of varying grain rations on the amount and the economy of production. A more direct study of the financial side of the operation is now in order. The table on page 388 exhibits:

1. The weights of the various fodders and feeds eaten.
2. The weights of milk and butter produced.
3. The money value[1] of the food eaten.
4. The cost of food for 100 pounds of milk and for 1 pound of butter.
5. Proceeds from butter sales at 20 cents a pound.[2]
6. The fertilizing value[3] of the rations.
7. The total value of all production (butter, skimmilk[4] and two-thirds of fertilizing ingredients).
8. Gain, net gain or loss, and daily net gain or loss when one ration is compared with another.

These are shown for the experimental portions of the periods only. Lactation changes are exactly equalled by calculation; hence each ration has the same chance as its rival to prove its worth.

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[1]Hay $10, silage $3, wheat bran $21.10, cottonseed meal $28, linseed meal $30, hominy feed $25, india wheat meal $32.75 (market prices for grain feeds in the winter of 1904-05 and the prices paid by the Station for india wheat). The prices used for roughage are relatively high, larger than those often used in calculations of this character. As the comparisons have only relative values, however, this is not a serious matter. It is referred to in order to forestall possible criticism as to the high cost for food of making a pound of butter. It would be easy to "figure" cheaper milk and butter.

[2]This is not the price the Station gets for its butter but simply a statement of average butter values of late years. It is, of course, a low price for winter creamery butter.

[3]Nitrogen 18½ cents, phosphoric acid 4 cents, potash 4¼ cents; 1905 trade values for the same ingredients of essentially similar availability in commercial fertilizers. It is uncertan how much of the plant food may reach the soil. This depends on many factors. It is conservative to estimate two-thirds as ultimately available.

[4]Allowing 20 cents a hundred for skimmilk, a low price in view of the present high prices for pork.

COMPARATIVE VALUES OF VARIOUS RATIONS FROM THE FINANCIAL STANDPOINT

Rations	Hay	Oat hay	Silage	Wheat bran	½ cottonseed meal ½ linseed meal	India wheat meal	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds from butter at 20 cents	Fertilizing value of food eaten
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	$	cts.	cts.	$	$
GRAIN FEEDS NOS. 1 AND 2. 138 DAYS ON EACH RATION													
No. 1,	1166	118	4403	731	372	...	2285	151.7	26.11	114.3	17.2	30.34	16.19
No. 2,	1173	132	4381	729	...	371	2166	144.1	26.85	124.0	18.6	28.82	13.34
No.2±No.1,							—119	—7.6	+0.74	+9.7	+1.4	—1.52	—2.85
Percentage differences,							— 5	— 5	+ 3	+ 8	+ 8	— 5	— 18

Total value of butter, skimmilk and two-thirds of fertilizing ingredients; No. 1 ration $45.14, No. 2 ration $41.51.

Difference in favor of No. 1 ration, $3.63.

Gain ($3.63), plus lessened cost ($0.74), gives net gain $4.37. daily net gain 3.17 cents.

GRAIN FEED NO. 2. 115 DAYS ON EACH RATION

No.2, I,	1031	52	3853	600	...	303	2089	122.8	22.48	107.1	18.3	24.56	11.11
No.2, II,	998	121	3896	610	...	310	2124	125.4	22.95	108.1	18.3	25.08	11.41
No.2, II±No.2, I,							+ 35	+2.6	+0.47	+1.0	0	+0.52	+0.30
Percentage differences,							+ 2	+ 2	+ 2	+ 1	0	+ 2	+ 3

Total value of butter, skimmilk, and two-thirds of fertilizing ingredients; No. 1 ration $35.62, No. 2 ration $36.39.

Difference in favor of No. 2 ration, $0.77.

Gain ($0.77), less extra cost ($0.47), gives net gain $0.30, daily net gain 0.26 cents.

GRAIN FEED NOS. 1 AND 3. 207 DAYS ON EACH RATION

No. 1,	1778	182	6639	1098	558	...	3798	229.3	39.47	103.9	17.2	45.86	24.44
No. 3,	1774	233	6594	552	545	544	3815	228.9	42.56	111.6	18.6	45.78	23.51
No.3±No.1,							+ 17	—0.4	+3.09	+7.7	+1.4	—0.08	—0.93
Percentage differences,							0	0	+ 8	+ 7	+8	0	— 4

Total value of butter, skimmilk, and two-thirds of fertilizing ingredients; No. 1 ration $68.81, No. 3 ration $68.12.

Difference in favor of No. 1 ration, $0.69.

Gain ($0.69), plus lessened cost ($3.09), gives net gain $3.78, daily net gain 1.83 cents.

GRAIN FEED NO. 3. 138 DAYS ON EACH RATION

No.3, I	1187	144	4079	372	366	366	2631	160.3	28.00	106.4	17.5	32.06	15.51
No.3, II	1173	139	4109	370	366	366	2599	158.3	28.01	107.8	17.7	31.66	15.42
No.3 I±No.3 II,							— 32	—2.0	+0.01	+1.4	+0.2	—0.40	—0.09
Percentage differences,							— 1	— 1	0	+ 1	+1	— 1	— 1

Total value of butter, skimmilk, and two-thirds of fertilizing ingredients; No. 1 ration $46.99, No. 2 ration $46.50.

Difference in favor of No. 1 ration, $0.49.

Gain ($0.49), plus lessened cost ($0.01), gives net gain $0.50, daily net gain 0.37 cents.

There is neither market for india wheat nor quotations of it, it being all locally ground for the growers. The Station paid an Orange county miller $32.75 per ton, a prohibitively high price for it, and paid freight in addition. Hence the money side of the comparison possesses little value, though given as a matter of record.

The tabular statement on page 388, so far as it relates to the comparison with wheat bran, is all inevitably in favor of the No. 1 ration. It made a little more milk, a trifle more butter, cost far less and made better manure. The total value of butter, skimmilk and two-thirds of the fertilizing ingredients for 207 days on each ration were: No. 1, $68.81; No. 3, $68.12; or 69 cents in its favor. It cost $3.09 less and figures a daily net gain per cow of 1.83 cents. In last year's trials the daily net gain per cow was 1.80 cents.[1]

If india wheat can be grown and ground at $20 a ton, it ought to be comparable to wheat bran at the same price. It should be remembered, however, that it is a "heavy" meal, that it does not possess the well-known mechanical properties of bran, and that it is less well adapted than is bran to form the bulk of a grain ration.

The table on page 388, so far as it has to do with the comparison between cottonseed and linseed meals, favors that ration. The usual calculations of the value of butter, skimmilk and two-thirds of the manurial constituents show for the No. 1, $45.14, and for the No. 2 ration, $41.51. The latter costs 74 cents more than did the former; hence the net gain

[1]Several of the tables of this character on pages 478 to 481, 497, 498, 506 and 507 in the last (seventeenth) report contained incorrect figures in the columns headed "Money value of food," "Cost of food for one hundred pounds of milk," and "Cost of food for one pound butter," as well as in the third line of reading matter beginning with the word "Gain." These errors were caused by the mixing up of multipliers in the hands of a person temporarily employed as computer and the failure of the party checking the work to observe the error. Thus, for example, the india wheat cost price ($32 a ton) was in some cases used where that for gluten meal ($28 a ton) should have been used. The validity of the discussions based on these tables is naturally affected somewhat. In only three cases (top of page 497, top of page 498, top of page 507) are the errors of any moment, all the others being of very minor importance. And in each of these three cases the corrected dàta is of the same character as that which was incorrect, that is to say, whatever the outcome as indicated inaccurately, it was actually in the same direction, only more so, being increased and emphasized by the substitution of the correct for the incorrect figures. In other words, the statements in print are understatements rather than the reverse. The three main errors are:

Page 494—Daily net gain per cow, No. 1 over No. 3 ration, 1.80 cents, instead of 0.93 cents.

Page 496—Daily net gain per cow, No. 1 over No. 2 ration, 2.21 cents, instead of 1.49 cents.

Page 505—Daily net gain per cow, No. 6 over No. 4 ration, 1.18 cents, instead of 0.70 cents.

The discussion immediately following this data on page 505 is in part unwarranted. These errors are thought to have been the first—other than printers' errors—occurring in the printed feeding trial data of this Station during ten years and are greatly deplored.

was $4.37 and the daily net gain 3.17 cents. In last year's trials this figure was 2.21 cents.[1]

Cottonseed and linseed meals cost less, made 5 percent more milk and butter and made much better manure. If india wheat can be grown and ground for $15 to $20 per ton there is a better show for its proving a successful competitor of the richer concentrates.

The two years' trials indicate the essential equality in feeding value of wheat bran and india wheat meal, and that the latter is a little poorer than is a mixture of half cottonseed and half linseed meals, when fed in quantities of less than three pounds daily. Quoting last year's report, "This outcome is not one which the analysis of the meal would have led one to anticipate. The cow in other words seems to find more milk-making food in india wheat than does the chemist." To buy it at $32, however, is folly.

III. THE FEEDING VALUE OF HOMINY FEED

Hominy chop (hominy feed) carries the same protein content, less starch, but more fat than does corn meal. Its considerable usage among dairymen and the lack of data experimentally obtained as to its merits as a feed for cows, prompted the Station to undertake to measure its merits last year and to repeat the trials this year.

1. Compared with Wheat Bran

Five fresh cows were used, four mature and one three years old. Three were fed rations Nos. 1 and 5 alternately, and two uniformly with No. 5. The seven continually fed No. 1 were also of avail here as in all the trials in which that ration was used.

COMPARISONS WITH STANDARDS

Wolff.—Sarnia and Ursula were underfed, eating too little of all nutrients; Fatima and Chi ate rather too little nitrogen-free extract matter; Lucerne hardly ate enough protein, while Chi did not consume quite enough protein when No. 1 was fed and was yet more stinted on No. 5.

Wolff-Lehmann.—Save for the impossible total dry matter requirement, every other bodily need as called for by this standard was met.

RESULTS

The outcome of this trial seems to be correctly summarized in Table VII, from which the following data are drawn:

It appears that when two and two-thirds pounds of hominy feed were substituted for an equal weight of wheat bran in an 8 pound grain ration containing bran, cottonseed and linseed meals,—one-half of the bran being thus replaced,—hay and silage being fed as roughage, there were in 207 days' feeding on each ration:

[1]Corrected. See footnote, page 389.

	No. 1 ration	No. 5 ration	Percentage gain or loss when No. 5 was fed[1]
Pounds of dry matter eaten,	4,506	4,485	0
Pounds of milk made,	2,640	2,816	+7
Percent of total solids,	15.72	15.66	0
Percent of fat,	5.93	5.88	—1
Pounds of total solids made,	413.6	439.6	+6
Pounds of fat made,	155.7	164.8	+6

and that to the 100 pounds of dry matter eaten there were made:

	No. 1 ration	No. 5 ration	Percentage gain or loss when No. 5 was fed[1]
Pounds of milk,	58.5	62.7	+7
Pounds of total solids,	9.2	9.8	+7
Pounds of fat,	3.46	3.68	+6
Ratio of fat to solids-not-fat; 1:	1.65	1.66	+1

These figures indicate that the hominy feed ration, both directly and per unit of dry matter made as compared with the full bran ration, 6 to 7 percent more milk, total solids, fat and butter. Last year it made 4 percent more milk, and but little more solids or butter. The bran fed last year was far better than was this year's product, which undoubtedly was a factor in the result. Both years hominy feed outranked bran as a milk producer and more than equalled it as a butter maker.

2. COMPARED WITH COTTONSEED AND LINSEED MEALS

Six cows were chosen, five mature, one a four-year-old, five from two to four months along in milk and one farrow. Four of these were fed rations Nos. 1 and 4 in alternation, and two were fed No. 4 continuously. The record of the seven cows fed No. 1 are also available.

[1]COMPARISON OF DIFFERENCE FIGURES (SEE NOTE TO TABLE VII APPENDIX, AS WELL AS FOOTNOTE, PAGE 384)

	Total dry matter eaten	Dry matter eaten in concentrates	Quantity of milk	Total solids, percent	Fat, percent	Quantity of total solids	Quantity of fat	Products per 100 pounds of dry matter: In entire ration: Milk	In entire ration: Total solids	In entire ration: Fat	In experimental feed: Milk	In experimental feed: Total solids	In experimental feed: Fat
Table VII,	0	0	+7	0	—1	+6	+6	+7	+7	+6	+7	+6	+6
Alternation,	+1	0	+7	+1	—1	+7	+6	+8	+7	+7	+7	+6	+6
Contin.-altern.,	0	0	+7	0	—2	+6	+5	+7	+7	+5	+8	+6	+5

COMPARISONS WITH STANDARDS

Wolff.—Every cow when eating the wide No. 4 ration necessarily ate too little protein. Lady Perusia, a heavy cow, ate too little of all nutrients. Stephanie when eating No. 1 got a shade too little nitrogen-free extract matter. Otherwise consumption was standard or more than standard.

Wolff-Lehmann.—Epsilon, a youngster giving a small flow, ate enough and to spare of all nutrients, even when eating on the wide No. 4 ration. No other cow when fed No. 4 ate enough protein. In all other respects the standard requirements were met or more than met—save, of course, those of total dry matter, which only Yttria and Epsilon made good.

RESULTS

The outcome of this trial is less well represented than is usually the case in this year's tests by the data derived from Table VII. Its figures and those attained by the alternation scheme of calculation are closely alike, but those obtained by the combined system are very unlike those furnished by the other two methods. A careful survey of the records made by the cows leads the writer to believe that irregularities occur in all the methods of calculation—not mathematical errors, but such as originate in bovine eccentricities—and that the truth probably lies between the two. One can only say, therefore, that the data in the next two tables represents the outcome as determined by one scheme of calculation, but that the results are probably understatements. With this qualification in mind, it may be claimed that when two and two-thirds pounds of hominy feed was substituted for an equal weight of a mixture of half cottonseed and half linseed meals, bran being also fed in each case, and hay and silage used as roughages, the results were as follows from 276 days' feeding on each ration:

	No. 1 ration	No. 4 ration	Percentage gain or loss when No. 4 was fed[1]
Pounds of dry matter eaten,	5,906	5,983	+1
Pounds of milk made,	4,396	4,297	—2
Percent of total solids,	15.31	15.33	0
Percent of fat,	5.52	5.33	0
Pounds of total solids,	658.1	647.6	—2
Pounds of fat made,	231.3	229.2	—1

and that to the 100 pounds of dry matter eaten there were made:

	No. 1 ration	No. 4 ration	Percentage gain or loss when No. 4 was fed[1]
Pounds of milk,	73.5	71.6	—3
Pounds of total solids,	11.0	10.8	—2
Pounds of fat,	3.87	3.81	—2
Ratio of fat to solids-not-fat; 1:	1.77	1.77	0

[1]See footnote [1] next page.

Taking into account the data afforded by the combined method (see footnote) it may be said that the cottonseed-linseed ration made from 3 to 5 percent more milk, total solids and fat, and from 2 to 4 percent more per unit of dry matter. In last year's trial the cottonseed-linseed ration made 2 percent less milk but 3 percent more butter, a profound change being observed in the quality of the milk. This odd result was not attained in other trials last year with hominy feed, nor is it in evidence this year. It seems to have been the exception which is said to prove the rule.

3. FINANCIAL CONSIDERATIONS

The tabular statement on page 395 shows that the No. 1 ration yielded in butter, skimmilk and two-thirds of the fertilizing ingredients, $57.23, and the No. 5 ration, $58.95. The former, however, cost 82 cents less, hence the net gain is only 90 cents and the daily net gain but 0.43 cents in favor of the No. 5 ration. It made $2.12 more butter, some 30 cents worth more skimmilk, though carrying over a dollar's worth less plant food. Last year the butter and skimmilk gain barely met the extra cost, thus swaying the pendulum to the side of the No. 1 ration because of its greater manurial content. Last year the No. 1 ration came out ahead by 0.64 cents daily net gain; this year the No. 5 by 0.43 cents daily net gain. It is the only case observed of materially dissimilar outcome, one year with the other. It is not unlikely that the uneven qualities of the brans fed in the 1904 and 1905 trials is a factor in the result.

[1] COMPARISON OF DIFFERENCE FIGURES (SEE NOTE TO TABLE VII APPENDIX, AS WELL AS FOOTNOTE, PAGE 384)

	Total dry matter eaten	Dry matter eaten in concentrates	Quantity of milk	Total solids, percent	Fat, percent	Quantity of total solids	Quantity of fat	Products per 100 pounds of dry matter					
								In entire ration			In experimental feed		
								Milk	Total solids	Fat	Milk	Total solids	Fat
Table VII,	+1	0	—2	0	0	—2	—1	—3	—2	—2	—2	—1	—1
Alternation,	+2	+1	—1	+1	+1	0	0	—2	—2	—2	—1	—1	—1
Contin.-altern.,	—2	—3	—7	+1	+3	—6	—5	—5	—5	—5	—3	—4	—3

The tabular statement shown below reveals the situation when viewed from the money standpoint. When each ration was fed 276 days the butter, skimmilk and fertilizing ingredients (the latter discounted a third) totalled for the No. 1 ration $82.94 and for the No. 4 ration, $78.73, a gain in favor of the former of $4.21. It cost only 84 cents more, however, making the net gain $3.37, or 12.2 cents a day, all of which was due to the increased plant food furnished by the richer byproducts. In other words, the extra 65 cents of butter and skimmilk made on the No. 1 ration did not quite compensate for its added cost. It would appear, then, that hominy meal at $25 did not compare favorably with cottonseed and linseed meals at $28 and at $30 respectively.

COMPARATIVE VALUES OF VARIOUS RATIONS FROM THE FINANCIAL STANDPOINT

Rations	Hay	Oat hay	Silage	Wheat bran	½ cottonseed meal ½ linseed meal	Hominy feed	Milk	Butter	Money value of food	Cost of food for 1 lb. butter	Cost of food for 100 lbs. of milk	Proceeds from butter at 20 cents	Fertilizing value of food eaten
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	$	cts.	cts.	$	$
GRAIN FEEDS NOS. 1 AND 4. 276 DAYS ON EACH RATION													
No. 1,	2269	269	8800	1427	723	...	4396	269.9	51.45	117.0	19.1	53.98	31.88
No. 4,	2294	243	8982	1449	...	732	4297	267.4	50.61	117.8	18.9	53.48	26.58
No.4±No.1,							— 99	—2.5	—0.84	+0.8	—0.2	—0.50	—5.30
Percentage differences,							— 2	— 1	— 2	+ 1	—1	— 1	— 17
GRAIN FEED NO. 4. 138 DAYS ON EACH RATION													
No.4 I,	1177	126	4621	731	...	371	2865	165.3	25.80	90.1	15.6	33.06	13.56
No.4 II,	1161	138	4594	731	...	372	2809	162.4	25.75	91.7	15.9	32.48	13.54
No.4 II±No.4 I,							— 56	—2.9	—0.05	+1.6	+0.3	—0.58	—0.02
Percentage differences,							— 2	— 2	0	+ 2	+2	—2	0

Total value of butter, skimmilk, and two-thirds of fertilizing ingredients; No. 1 ration $82.94, No. 4 ration $78.73.

Difference in favor of No. 1 ration, $4.21.

Gain ($4.21), less extra cost ($0.84), gives net gain $3.37, daily net gain 1.22 cents.

Total value of butter, skimmilk, and two-thirds of fertilizing ingredients; No. 1 ration $47.11, No. 2 ration $46.43.

Difference in favor of No. 1 ration, $0.68.

Gain ($0.68), less extra cost ($0.05), gives net gain $0.63, daily net gain 0.46 cents.

Rations	Hay	Oat hay	Silage	Wheat bran	½ cottonseed meal ½ linseed meal	India wheat meal or hominy feed	Milk	Butter	Money value of food	Cost of food for 1 lb. butter	Cost of food for 100 lbs. of milk	Proceeds from butter at 20 cents	Fertilizing value of food eaten
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	$	cts.	cts.	$	$
GRAIN FEEDS NOS. 1 AND 5. 207 DAYS ON EACH RATION													
No. 1,	1729	213	6634	1095	558	...	2640	181.7	39.32	148.9	21.6	36.34	24.41
No. 5,	1723	198	6566	556	548	548	2816	192.3	40.14	142.5	20.9	38.46	23.32
No.5±No.1,							+176	+10.6	+0.82	—6.4	—0.7	+2.12	—1.09
Percentage differences,							+ 7	+ 6	+ 2	— 4	— 3	+ 6	—4

Total value of butter, skimmilk, and two-thirds of fertilizing ingredients; No. 1 ration $57.23, No. 5 ration $58.95.

Difference in favor of No. 5 ration, $1.72.

Gain ($1.72), less extra cost ($0.82), gives net gain $0.90, daily net gain 0.43 cents.

Rations	Hay	Oat hay	Silage	Wheat bran	½ cottonseed meal ½ linseed meal	India wheat meal or hominy feed	Milk	Butter	Money value of food	Cost of food for 1 lb. butter	Cost of food for 100 lbs. of milk	Proceeds from butter at 20 cents	Fertilizing value of food eaten
GRAIN FEED NO. 5. 138 DAYS ON EACH RATION													
No.5 I,	1076	129	4636	406	401	401	1995	118.6	28.12	141.0	23.7	23.72	16.26
No.5 II,	1083	128	4665	408	402	402	1937	115.5	28.21	145.6	24.4	23.10	16.28
No.5 II±No.5 I,							— 58	—3.1	+0.09	+4.6	+0.7	—0.62	+0.02
Percentage differences,							— 3	— 3	0	+ 3	+ 3	— 3	0

Total value of butter, skimmilk, and two-thirds of fertilizing ingredients; No. 1 ration $38.05, No. 2 ration $37.34.

Difference in No. 1 ration, $0.71.

Gain ($0.71), plus lessened cost ($0.09), gives net gain $0.80, daily net gain 0.58 cents.

IV. THE FEEDING VALUES OF COTTONSEED AND LINSEED MEALS

Cottonseed and linseed meals have been standard feeds for several decades. Their position in the feeding world is well established and, as "good wine needs no bush," so they ought to need no further demonstration of their merits. Yet they are still too little used, particularly the linseed meal. Then, too, it has so happened that no trials of their relative merits have been thus far carried out at this Station in all the years of its work along feeding lines. Opportunity offering, a somewhat extended test has been made wherein feed mixtures Nos. 1 and 6, Nos. 1 and 7 and Nos. 6 and 7 were competitively fed one against the other. No. 6 differs from No. 1 in containing two and two-third pounds of cottonseed meal in lieu of one and one-third pounds cottonseed and one and one-third pounds linseed. No. 7 differs from No. 1 in containing two and two-thirds pounds of linseed meal in and two-thirds pounds of cottonseed meal in lieu of one and one-third pounds cottonseed meal. And No. 6 differs from No. 7 in carrying two

and two-thirds pounds cottonseed meal instead of two and two-thirds pounds linseed meal. Each ration carried five and one-third pounds wheat bran. Thus the substitution of No. 6 or of No. 7 for No. 1 made a minor change, and of No. 6 for No. 7 or *vice versa* a considerable one.

Twenty cows were used in this trial, all but two five years old or more, the two exceptions being four-year-olds. Eighteen of them calved between August 3 and November 28 and were, therefore, in good condition so far as milk flow was concerned for the trial. One of the others calved in April, the other in the preceding December, but was served only a month before the trials opened. Three were fed rations Nos. 1 and 6 in alternation, three Nos. 1 and 7 and three Nos. 6 and 7; two were fed uniformly No. 6, two No. 7, while seven ate a constant ration—No. 1—and furnished a means of comparison not only in these but also in the other trials already discussed.

COMPARISON WITH STANDARDS

Wolff.—Nine of the twenty cows ate as much—or more—of all the nutrients as the standard required, though two of them at times were hardly eating standard amounts. The food consumption of five others was quite constantly short of standard requirements, but it was only a slight shortage. Constance and Laura did not eat enough nitrogen-free extract matter; Janice was not only shy in her use of this nutrient, but also of protein; while Star Bright, Rosel and Adelaide each failed decidedly to eat enough to meet the dictum of Wolff.

Wolff-Lehmann.—Elsie, Vivian, Yemassee and Yuba ate too little of all nutrients; Rosel ate too little nitrogen-free extract matter and too little digestible dry matter. Otherwise the eating was standard or superstandard, bar that of total dry matter. It seems wise to consider first the results from the two minor changes, taking first the substitution of the smaller amount of cottonseed meal for the linseed.

RESULTS

The result of this trial seems fairly measured by the data presented in Table VII in the appendix. These indicate that when grain feeds Nos. 1 and 6 were fed, each for 207 days, with hay and silage as roughages, there were:

	No. 1 ration	No. 6 ration	Percentage gain or loss when No. 6 was fed[1]
Pounds of dry matter eaten,	4,321	4,359	+1
Pounds of milk made,	3,860	3,998	+4
Percent total solids,	15.26	15.36	+1
Percent fat,	5.72	5.76	+1
Pounds of total solids made,	584.7	608.7	+4
Pounds of fat made,	216.9	226.2	+4

[1]See footnote [1] next page.

This trial further shows that there were made to the 100 pounds of dry matter eaten:

	No. 1 ration	No. 6 ration	Percentage gain or loss when No. 6 was fed[1]
Pounds of milk,	88.1	90.5	+3
Pounds of total solids,	13.4	13.8	+3
Pounds of fat,	4.97	5.14	+3
Ratio of fat to solids-not-fat; 1:	1.67	1.67	0

The outcome is clear-cut and is identical whichever way the case is figured, viz., a 4 percent gain in production and a 3.5 percent gain per unit of dry matter eaten when the cottonseed meal replaced the linseed meal.

What is the situation when the linseed replaced the cottonseed? The data in Table VII seemed fairly safe to use. These indicate the following result when grain feeds Nos. 1 and 7 were fed each for 207 days, with hay and silage as roughages:

	No. 1 ration	No. 7 ration	Percentage gain or loss when No. 7 was fed[2]
Pounds of dry matter eaten,	4,448	4,411	—1
Pounds of milk made,	3,059	3,073	0
Percent total solids,	15.12	15.04	—1
Percent fat,	5.58	5.50	—1
Pounds of total solids made,	461.6	461.7	0
Pounds of fat made,	169.5	168.3	—1

and that there were made to the 100 pounds of dry matter eaten:

	No. 1 ration	No. 7 ration	Percentage gain or loss when No. 7 was fed[2]
Pounds of milk,	68.6	69.5	+1
Pounds of total solids,	10.4	10.5	+1
Pounds of fat,	3.80	3.81	0
Ratio of fat to solids-not-fat; 1:	1.71	1.73	+1

[1] COMPARISON OF DIFFERENCE FIGURES (SEE NOTE TO TABLE VII APPENDIX, AS WELL AS FOOTNOTE, PAGE 384)

	Total dry matter eaten	Dry matter in experimental feed	Quantity of milk	Total solids, percent	Fat, percent	Quantity of total solids	Quantity of fat	Products per 100 pounds of dry matter: In entire ration: Milk	In entire ration: Total solids	In entire ration: Fat	In experimental feed: Milk	In experimental feed: Total solids	In experimental feed: Fat
Table VII,	+1	0	+4	+1	+1	+4	+4	+3	+3	+3	+3	+3	+4
Alternation,	—1	+1	+4	+1	+1	+5	+5	+3	+3	+3	+3	+4	+4
Contin.-altern.,	0	0	+4	0	0	+4	+4	+4	+5	+4	+4	+4	+4

[2]See footnote [1] on next page.

The outcome is less clear here than in the first comparison, owing to the unlikeness of the combined data due to obvious incongruities in the calculations (see next article). The Table VII and alternation data are more trustworthy. Their testimony is that the result is practically a tie, the two rations being of equal value.

What is the outcome when Nos. 6 and 7 were pitted against each other?

The outcome of this trial seems to be correctly summarized in Table VII, from which the following data are drawn:

It appears that when two and two-thirds pounds of linseed meal were substituted for an equal weight of cottonseed meal in an 8 pound grain ration containing bran,—hay and silage being fed as roughages—there were in 207 days' feeding on each ration:

	No. 6 ration	No. 7 ration	Percentage gain or loss when No. 7 was fed[2]
Pounds of dry matter eaten,	4,422	4,497	+2
Pounds of milk made,	3,670	3,589	—2
Percent total solids,	14.72	14.53	—1
Percent fat,	5.21	5.11	—2
Pounds of total solids made,	530.6	513.4	—3
Pounds of fat made,	183.5	177.4	—3

and that to the 100 pounds of dry matter eaten there were made:

	No. 6 ration	No. 7 ration	Percentage gain or loss when No. 7 was fed[2]
Pounds of milk,	82.6	79.7	—4
Pounds of total solids,	12.0	11.4	—5
Pounds of fat,	4.14	3.94	—5
Ratio of fat to solids-not-fat; 1:	1.83	1.84	+1

[1] COMPARISON OF DIFFERENCE FIGURES (SEE NOTE TO TABLE VII APPENDIX, AS WELL AS FOOTNOTE, PAGE 384)

	Total dry matter	Dry matter eaten in concentrates	Quantity of milk	Total solids, percent	Fat, percent	Quantity of total solids	Quantity of fat	Products per 100 pounds of dry matter					
								In entire ration			In experimental feed		
								Milk	Total solids	Fat	Milk	Total solids	Fat
Table VII,	—1	—2	0	—1	—1	0	—1	+1	+1	0	+2	+2	+1
Alternation,	—2	—4	0	—1	—2	—1	—2	+2	+1	+1	+3	+2	+1
Contin.-altern.,	0	—1	—8	—1	—3	—8	—9	—6	—8	—11	—5	—6	—10

[2]See footnote [1] on next page.

The outcome is clear again here and all in one direction, albeit rather over-emphasized by the combined scheme of calculation, namely, a 2 to 3 percent loss in production when linseed meal replaced the cottonseed, and a 4 to 5 percent loss in proportion to dry matter eaten.

How do the three pieces of testimony compare?

1. A 3.5 to 4 percent gain when a small amount of cottonseed meal replaced the linseed meal.

2. No gain when a small amount of linseed meal replaced the cottonseed.

3. A 2 to 5 percent loss when a considerable quantity of linseed meal replaced the cottonseed meal.

These three results seem to concur essentially in according a small though measurable advantage to the cottonseed ration.

FINANCIAL CONSIDERATIONS

Since the cottonseed meal cost less than did the linseed meal, yet made more milk and butter and was richer in manurial ingredients, it follows that it necessarily came out ahead in each trial. The tables pages 400-402 furnish ample evidence. Their saliant points are:

[1]COMPARISON OF DIFFERENCE FIGURES (SEE NOTE TO TABLE VII APPENDIX, CONSTITUENTS

No. 1	$73.09	No. 6	$76.19
No. 1	60.83	No. 7	59.99
No. 6	65.73	No. 7	63.34

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[1] COMPARISON OF DIFFERENCE FIGURES (SEE NOTE TO TABLE VII APPENDIX, AS WELL AS FOOTNOTE, PAGE 384)

	Total dry matter eaten	Dry matter eaten in concentrates	Quantity of milk	Total solids, percent	Fat, percent	Quantity of total solids	Quantity of fat	Products per 100 pounds of dry matter: In entire ration: Milk	Products per 100 pounds of dry matter: In entire ration: Total solids	Products per 100 pounds of dry matter: In entire ration: Fat	Products per 100 pounds of dry matter: In experimental feed: Milk	Products per 100 pounds of dry matter: In experimental feed: Total solids	Products per 100 pounds of dry matter: In experimental feed: Fat
Table VII,	+2	+1	—2	—1	—2	—3	—3	—4	—5	—5	—3	—4	—4
Alternation,	+1	+1	—2	—1	—1	—3	—3	—3	—5	—5	—2	—4	—4
Contin.-altern.,	+1	+2	—4	—2	—3	—6	—7	—4	—6	—7	—3	—7	—7

DAILY NET GAINS PER COW

No. 6 over No. 1 .... 1.47 cents
No. 1 over No. 7 .... 0.43 cents
No. 6 over No. 7 .... 1.62 cents

In these trials cottonseed meal, even the relatively poor grade fed, won out handily as compared with linseed meal. Yet the writer believes that the latter is an advisable concomitant to use with cottonseed, because of its laxative properties. A high cottonseed ration fed Jersey cows is apt to make, moreover, a hard and crumbly butter, a condition which an addition of linseed meal tends to ameliorate.

COMPARATIVE VALUES OF VARIOUS RATIONS FROM THE FINANCIAL STANDPOINT

Rations	Hay	Oat hay	Silage	Wheat bran	Cottonseed meal	Linseed meal	Milk	Butter	Money value of food	Cost of food for 1 lb. butter	Cost of food for 100 lbs. of milk	Proceeds from butter at 20 cents	Fertilizing value of food eaten
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	$	cts.	cts.	$	$
GRAIN FEEDS NOS. 1 AND 6. 207 DAYS ON EACH RATION													
No. 1,	1710	160	6049	1089	277	276	3860	253.0	37.95	98.3	15.0	50.60	23.58
No. 6,	1719	209	6017	1097	556	...	3998	263.9	38.01	95.1	14.4	52.78	24.61
No.6±No.1,							+138	+10.9	+0.06	—3.2	—0.6	+2.18	+1.03
Percentage differences,							+ 4	+ 4	0	— 3	— 4	+ 4	+ 4

Total value of butter, skimmilk, and two-thirds of fertilizing ingredients; No. 1 ration $73.09, No. 6 ration $76.19.
Difference in favor of No. 6 ration, $3.10.
Gain ($3.10), less extra cost ($0.06), gives net gain $3.04, daily net gain 1.47 cents.

Rations	Hay	Oat hay	Silage	Wheat bran	Cottonseed meal	Linseed meal	Milk	Butter	Money value of food	Cost of food for 1 lb. butter	Cost of food for 100 lbs. of milk	Proceeds from butter at 20 cents	Fertilizing value of food eaten
GRAIN FEED NO. 1. 138 DAYS ON EACH RATION													
No.1, I,	1127	133	4662	732	186	186	2478	142.3	26.44	106.7	18.6	28.46	16.35
No.1, II,	1105	124	4668	732	186	186	2405	138.1	26.30	109.4	19.0	27.62	16.25
No.1 II±No.1 I,							— 73	— 4.2	—0.14	+2.7	+0.4	—0.84	—0.10
Percentage differences,							— 3	— 3	— 1	+ 3	+ 2	— 3	— 1

Total value of butter, skimmilk, and two-thirds of fertilizing ingredients; No. 1 ration $43.70, No. 2 ration $42.68.
Difference in favor of No. 1 ration, $1.02.
Gain ($1.02), less extra cost ($0.14), gives net gain $0.88, daily net gain 0.64 cents.

COMPARATIVE VALUES OF VARIOUS RATIONS FROM THE FINANCIAL STANDPOINT

Rations	Hay	Oat hay	Silage	Wheat bran	Cottonseed meal	Linseed meal	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds from butter at 20 cents	Fertilizing value of food eaten
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	$	cts.	cts.	$	$
GRAIN FEED NO. 6. 69 DAYS ON EACH RATION													
No.6, 1,	594	42	2313	366	185	...	1175	68.7	13.13	111.7	19.1	13.74	8.38
No.6, II,	561	75	2325	366	186	...	1142	66.3	13.16	115.2	19.8	13.26	8.43
No.6 II±No.6 I,							— 33	— 2.4	+0.03	+3.5	+0.7	—0.48	+0.05
Percentage differences,							— 3	— 3	0	+ 3	+ 4	— 3	+ 1

Total value of butter, skimmilk, and two-thirds of fertilizing ingredients; No. 1 ration $21.38, No. 2 ration $20.88.

Difference in favor of No. 1 ration, $0.50.

Gain ($0.50), plus lessened cost ($0.03), gives net gain $0.53, daily net gain 0.77 cents.

Rations	Hay	Oat hay	Silage	Wheat bran	Cottonseed meal	Linseed meal	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds from butter at 20 cents	Fertilizing value of food eaten
GRAIN FEED NO. 1. 69 DAYS ON EACH RATION													
No. 1, I,	590	80	2033	366	93	93	1231	78.2	12.99	105.5	16.6	15.64	8.11
No. 1, II,	566	98	2052	364	93	93	1283	82.4	12.97	100.9	15.7	16.48	8.08
No. 1 II±No. 1 I,							+ 55	+ 4.2	—0.02	—4.6	—0.9	+0.84	—0.03
Percentage differences,							+ 4	+ 5	0	— 4	— 5	+ 5	0

Total value of butter, skimmilk, and two-thirds of fertilizing ingredients; No. 1 ration $23.20, No. 2 ration $24.12.

Difference in favor of No. 2 ration, $0.92.

Gain ($0.92), plus lessened cost ($0.02), gives net gain $0.94, daily net gain 1.36 cents.

Rations	Hay	Oat hay	Silage	Wheat bran	Cottonseed meal	Linseed meal	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds from butter at 20 cents	Fertilizing value of food eaten
GRAIN FEEDS NOS. 1 AND 7. 207 DAYS ON EACH RATION													
No. 1,	1717	174	6612	1075	271	271	3059	197.8	38.55	126.0	19.5	39.56	23.87
No. 7,	1693	192	6651	1056	...	537	3073	196.4	38.61	125.6	19.7	39.28	23.01
No. 7±No. 1,							+14	—1.4	+0.06	—0.4	+0.2	—0.28	—0.86
Percentage differences,							0	— 1	0	0	+ 1	— 1	— 4

Total value of butter, skimmilk, and two-thirds of fertilizing ingredients; No. 1 ration $60.83, No. 7 ration $59.99.

Difference in favor of No. 1 ration, $0.84.

Gain ($0.84), plus lessened cost ($0.06), gives net gain $0.90, daily net gain 0.43 cents.

Rations	Hay	Oat hay	Silage	Wheat bran	Cottonseed meal	Linseed meal	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds from butter at 20 cents	Fertilizing value of food eaten
GRAIN FEED NO. 1. 276 DAYS ON EACH RATION													
No.1 I,	2271	274	9362	1462	372	372	5060	309.2	52.96	104.7	17.1	61.84	32.82
No.1 II,	2268	272	9295	1464	372	372	5071	313.6	52.88	104.3	16.9	62.72	32.75
No. 1 II±No. 1 I,							+11	+4.4	—0.08	—0.4	—0.2	+0.88	—0.07
Percentage differences,							0	+ 1	0	0	— 1	+ 1	0

Total value of butter, skimmilk, and two-thirds of fertilizing ingredients; No. 1 ration $92.59, No. 2 ration $93.44.

Difference in favor of No. 2 ration, $0.85.

Gain ($0.85), plus lessened cost ($0.08), gives net gain $0.93, daily net gain 0.34 cents.

COMPARATIVE VALUES OF VARIOUS RATIONS FROM THE FINANCIAL STANDPOINT

Rations	Hay	Oat hay	Silage	Wheat bran	Cottonseed meal	Linseed meal	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds from butter at 20 cents	Fertilizing value of food eaten
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	$	cts.	cts.	$	$
GRAIN FEED NO. 7. 69 DAYS ON EACH RATION													
No. 7, I,	579	46	2106	366	...	186	828	49.6	12.96	156.5	26.1	9.92	7.73
No. 7, II,	567	87	2198	366	...	186	858	51.3	13.22	154.1	25.8	10.26	7.92
No. 7 II±No. 7 I,							+30	+1.7	+0.26	—2.4	—0.3	+0.34	+0.19
Percentage differences,							+ 4	+ 3	+ 2	— 2	— 1	+ 3	+ 2

Total value of butter, skimmilk, and two-thirds of fertilizing ingredients; No. 1 ration $16.52, No. 2 ration $17.04.

Difference in favor of No. 2 ration, $0.52.

Gain ($0.52), less extra cost ($0.26), gives net gain $0.26, daily net gain 0.38 cents.

Rations	Hay	Oat hay	Silage	Wheat bran	Cottonseed meal	Linseed meal	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds from butter at 20 cents	Fertilizing value of food eaten
GRAIN FEEDS NOS. 6 AND 7. 207 DAYS ON EACH RATION													
No. 6,	1686	214	6559	1083	545	...	3670	214.1	38.43	104.7	18.0	42.82	24.72
No. 7,	1742	172	6645	1093	...	554	3589	207.0	39.40	109.8	19.0	41.40	23.49
No. 7±No. 6,							—81	—7.1	+0.97	+5.1	+1.0	—1.42	—1.23
Percentage differences,							— 2	— 3	+ 3	+ 5	+ 6	— 3	— 5

Total value of butter, skimmilk, and two-thirds of fertilizing ingredients; No. 6 ration $65.73, No. 7 ration $63.34.

Difference in favor of No. 6 ration, $2.39.

Gain ($2.39), plus lessened cost ($0.97), gives net gain $3.36, daily net gain 1.62 cents.

Rations	Hay	Oat hay	Silage	Wheat bran	Cottonseed meal	Linseed meal	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds from butter at 20 cents	Fertilizing value of food eaten
GRAIN FEED NO. 6. 69 DAYS ON EACH RATION													
No. 6, I,	528	27	1968	363	181	...	642	41.9	12.10	188.5	28.9	8.38	7.78
No. 6, II,	503	45	2039	365	185	...	632	41.1	12.25	193.9	29.8	8.22	7.87
No. 6 II±No. 6 I,							—10	—0.8	+0.15	+5.4	+0.9	—0.16	+0.09
Percentage differences,							— 2	— 2	+ 1	+ 3	+ 3	— 2	+ 1

Total value of butter, skimmilk and two-thirds of fertilizing ingredients; No. 1 ration $14.69, No. 2 ration $14.58.

Difference in favor of No. 1 ration, $0.11.

Gain ($0.11), plus lessened cost ($0.15), gives net gain $0.26, daily net gain 0.37 cents.

Rations	Hay	Oat hay	Silage	Wheat bran	Cottonseed meal	Linseed meal	Milk	Butter	Money value of food	Cost of food for 100 lbs. of milk	Cost of food for 1 lb. butter	Proceeds from butter at 20 cents	Fertilizing value of food eaten
GRAIN FEED NO. 7. 69 DAYS ON EACH RATION													
No. 7, I,	599	52	2061	366	...	186	1171	78.6	13.02	111.2	16.6	15.72	7.77
No. 7, II,	576	84	2061	366	...	186	1179	80.0	13.05	110.5	16.3	16.00	7.83
No. 7 II±No. 7 I,							+8	+1.4	+0.03	—0.7	—0.3	+0.28	+0.06
Percentage differences,							+1	+ 2	0	— 1	— 2	+ 2	+ 1

Total value of butter, skimmilk and two-thirds of fertilizing ingredients; No. 1 ration $22.95, No. 2 ration $23.20.

Difference in favor of No. 2 ration, $0.25.

Gain ($0.25), less extra cost ($0.03), gives net gain $0.22, daily net gain 0.32 cents.

V. EXPERIMENTAL ERROR

There yearly accumulates in the regular course of the feeding trials much data touching the experimental error involved in the alternation method of conducting feeding trials, which this year as usual is placed upon permanent record.[1]

Nineteen cows were fed unaltered rations throughout the course of the trials, old, middle-aged and young cows, fresh cows, cows in mid-lactation and those far along towards calving. If their records be treated as if they were fed different rations in alternate periods, a measure of the extent of experimental error is obtained.

RESULTS

At various points in the appendix, in Tables VI and VII, are data showing increase or decrease—expressed as percentages—in dry matter eaten, in milk, in total solids and fat given, and of product per 100 pounds of dry matter eaten, when unchanged rations were fed. It does not seem necessary to collate them at this point in one table. The results include 22 sets and 297 separate figures. These are distributed as follows: 98 zeros, 94 ones, 50 twos, 37 threes, 11 fours, 5 fives and 2 sixes. Ninety-four percent of the figures are threes or less, 2 percent are fives or higher. The average value is 1.3, a fine showing.

It may be worth while gathering together the last five years' work along this line:

Year	Sets	Number of figures	Average values
1905,	22	297	1.30
1904,	34	459	2.32
1903,	25	336	2.47
1902,	20	270	1.47
1901,	14	122	1.36

In three of the five years a thoroughly satisfactory outcome has been attained; in two a very unsatisfactory one, high figures being caused always by the eccentricities of single cows. In no case where the records of two or more cows are used do large figures occur. The negligibility of the experimental error in the alternation method when adequate numbers of animals are used and proper choices are made has been often affirmed and is confirmed by the present year's testimony.

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[1]Vt. Sta. Rpts., 3, pp. 62-64 (1889); 9, pp. 225-228 (1895); 10, pp. 165-167 (1897); 11, pp. 339-340 (1898); 12, pp. 286-287 (1899); 14, pp. 365-366 (1901); 15, pp. 314-316 (1902); 16, pp. 259-263 (1903); 17, pp. 508-510 (1904).

VI. SUMMARY

The details given in the foregoing pages—377-403—may be summarized as follows:

The nature of the problems studied.—Forty-two cows were used in feeding trials which lasted twenty-five weeks and were meant to aid in the determination, so far as it is possible for single trials to do, of the feeding values of:

(*a*) India wheat meal—pages 383-390.

(*b*) Hominy feed—pages 390-395.

(*c*) Cottonseed meal—pages 395-402.

(*d*) Linseed meal—pages 395-402.

(*e*) The extent of experimental error in feeding trials by the alternation method—page 403.

India wheat meal, used in medium to small amounts seemed a fair substitute, pound for pound, of wheat bran, and nearly so of a mixture of equal parts of cottonseed and linseed meals, an outcome which its analysis would not have led one to expect and which has been confirmed by the concordant results of two season's trials.

Hominy feed proved superior as a milk-maker to a rather inferior grade of wheat bran, but did not appear to be the equal of cottonseed and linseed meals, nor was it as economical a concentrate to use. This outcome has, likewise, the coincident testimony of two years' trials to back it.

Cottonseed meal, as compared with linseed meal, seemed to possess a small though measurable advantage as a milk and butter making byproduct; and since it cost less and carried a greater plant food content, it proved economically preferable.

Experimental error, when six to eight animals are fed by the alternation system, may be held to be a negligible quantity.

A COMPARISON OF FEEDING TRIAL METHODS

(Fifth Article)

JOSEPH L. HILLS

The data submitted herewith and the deductions drawn therefrom are the fifth contribution[1] of this Station to the study of this particular matter. The reasons for so much repetition, as well as the underlying motives which have prompted the pursuit of this particular line of inquiry, have been hitherto discussed. The trials were made as in previous years with a view of noting the relative trustworthiness of two systems of measurement of the value of feeding rations for cows:

1. When the competing rations are fed to the same cows in successive periods in alternation, as for example, ration A for five weeks (Period I); B for the next five weeks (Period II); A for the third five weeks (Period III), and so on, (the simple alternation system).

2. When the competing rations are fed to three groups of cows; to one, in alternation as above outlined; to another, one of the rations fed continuously; and to the third, the other ration fed continuously. These groups are supposed to be so constituted that the cows enter the feeding trials in as nearly as may be an even condition, apparently capable of making essentially the same quantities of milk and butter for some months to come if similarly fed and treated. The differences in yields, etc., actually observed when divergencies in feeding occur with one of the groups, are held to be the measurements of food values (the system of combined continuity and alternation).

Both methods of measurement were employed in the trials of 1904-05. Forty-two cows, twenty-three fed according to the first and nineteen according to the second system outlined above, were chosen, being as carefully paired according to the scheme of the combined system as might be. Experience in the past, however, has proved that it is better to make use of the records actually obtained rather than to limit the study simply to the record of the cows arbitrarily paired at the outset.[2]

The previous articles have contained tabular summaries showing the character of the couplings,[3] and giving the age, days since calving, months to next calving, and the record (i. e. milk, total solids and fat

[2]For former articles see Vt. Sta. Rpts., 14, pp. 369-375 (1901); 15, pp. 318-327 (1902); 16, pp. 264-274 (1903); 17, pp. 511-523 (1904).

[2]See in this connection pages 512-513 of the last report.

[3]"Couple" is a term used to designate two cows thought to possess essentially the same milk and butter making abilities for the purposes of the experimental work in hand as outlined in the description of method 2.

yield, with percentages) during the first period (23 days) when the comparison was instituted for each cow. This table is a somewhat formidable one, and, moreover, is none too clear. It seems best to omit it, to state simply the animals and periods and to present the customary classification of the couplings. Anyone interested can readily gather the data for any or all the couplings from the tables in the appendix.

Each cow whose name appears in the first paragraph was continuously fed some one ration. Each whose name appears in the second paragraph was fed different rations in alternate periods. The letters A to C C, and figures 1 to 31, are simply reference figures. The roman numerals I, II and III following each name refer to the numbers of those periods the records of which are compared. For example, a comparison of records shows that Lavender, fed No. 1 ration continuously, and Edith, fed Nos. 1 and 3 in alternation, made closely similar records in the first feeding period when each ate the No. 1 ration. These records are consequently used and are denominated A 3 (their reference numbers).

A, Lavender—I; B, Vivian—I; C, Cassandra—I; D, Yemassee—I; E, Mu—I; F, Mermaid—I; G, Rosel—I; H, Lavender—II; I, Vivian—II K, Yemassee—II; L, Lavender—III; M, Vivian—III; N, Cassandra—III; O, Yemassee—III; P, Mu—III; Q, Mermaid—III; R, Rosel—III; S, Eva—II; T, Zeta—II; U, Una—II; V, Santa Rosa—I; W, Santa Rosa—II; X, Rebecca—I; Y, Rebecca—III; Z, Laura—II; AA, Janice—II; BB, Janice—III; CC, Myrtle—II.

1, Elizabeth—I; 2, Zirconia—I; 3, Edith—I; 4, Stephanie—I; 5, Chi—I; 7, Gamma—I; 9, Star Bright—I; 10, Yttria—II; 11, Lucerne—II; 13, Zirconia—III; 15, Stephanie—III; 16, Chi—III; 18, Constance—III; 19, Gamma—III; 20, Alta—III; 22, Elizabeth—II; 23, Zirconia—II; 24, Stephanie—II; 25, Yttria—I; 26, Yttria—III; 28, Alta—II; 29, Adelaide—III; 30, Judith—II; 31, Zillah—II.

A careful survey of the records made in the first of three periods necessary to make a completed record for each cow, leads to the following classification of the 46 matches: Good, 20; fair to indifferent, 19; poor, 7.

Good—A3, A9, B4, C1, D2, E1, F1, F7, H11, I10, L16, L18, M15, N20, O15, P20, R13, T23, Y26, CC28.

Fair to indifferent—A5, C2, C7, D1, D4, E2, E7, G1, K10, N19, O19, Q20, S22, V23, V25, W24, Z31, AA30, BB29.

Poor—G2, N13, P13, P19, Q19, R20, X25.

The plan of experimental feeding, the comparison with standards and the general results were discussed within pages 377 and 400. It simply remains to consider the final results as measured by the two

methods of experimentation. To print all of the calculated data seems unnecessary and a single example of the method of determination may suffice.

TABULATED STATEMENT COMPARING THE TWO METHODS[1]

Number of period of comparison	Total dry matter in entire ration	Total dry matter in experimental feed	Quantity of milk	Percent of total solids	Percent of fat	Quantity of total solids	Quantity of fat	Products per 100 pounds of dry matter					
								In entire ration			In experimental feed		
								Milk	Total solids	Fat	Milk	Total solids	Fat
Showing the increase or decrease, as the case may be, of the record of each cow in period II, as compared with the average of the records of periods I and III.													
Cassandra, uniform feeding on No. 1 ration													
II,	+1	—1	+3	0	—1	+4	+3	+3	+3	+2	+5	+5	+4
Elizabeth, fed No. 1 in I and III periods, No. 2 in II period													
II,	—2	—3	—8	+2	+3	—6	—4	—7	—4	—3	—5	—2	—1
Results (±) of change in ration as measured by Elizabeth's record in comparison with Cassandra's,	—3	—2	—11	+2	+4	—10	—7	—10	—7	—5	—10	—7	—5

[1]The following explanations may serve to make this table and its meaning more clear. The cows Cassandra and Elizabeth, at the opening of the trials in December, gave promise of making much the same amounts of milk and butter, and of making milk of essentially uniform character during the next six months, provided they were similarly treated and fed. Cassandra was thus handled, being fed a uniform grain ration (No. 1) for 25 weeks. Elizabeth, however, was not, since she alternated from the No. 1 to the No. 2 ration and back again. In the second period Cassandra made 3 percent more milk than she did on the average in the first and third periods of the unchanged ration. Elizabeth made 8 percent less at the same time, due perhaps to her changed grain ration. It is assumed that her milk flow, like that of her mate's, would have increased 3 percent had she, like her, been kept on the unchanged diet; that the same influences that caused Cassandra to increase but 3 percent in her milk flow would have brought about a similar change with Elizabeth. But she shrank 8 percent instead of gaining 3 percent, a difference of 11 percent. Hence —11 (or 11 percent of the total which equals 100) is the measure, in this particular case, of the effect of the changed ration on the milk flow. All the other items, the quality of the milk, the pounds of total solids and fat, and the same proportioned to the unit of dry matter, are similarly calculated. These plus and minus changes, gains and losses, as a result of varying rations, are the measures of the worth of the two rations by the combined method of continuity and alternation.

Since these comparisons can only be made when the cow alternately fed varying rations eats the same one as her mate in the first and last period under comparison and the other ration in the intermediate period, the number of observations are limited at best to two for each couple and in some cases to but one. Forty-six comparisons only can be made as compared with 117 made by the alternation method.

Now the question arises, how do these 46 results arrived at by the combined continuous-alternating method compare with those obtained by the simple alternation system? The data secured by the latter method are given at sundry points in the appendix and in connection with the previous article. The table on the next page shows them condensed and compared with those derived in the manner just indicated by the combined system. The first line in each triad, with the reference number I-XII at the left, represents the results attained by the combined method; the second line, which bears the ration change data (e. g. 1-2) at the left, shows the results derived by the simple alternation scheme of trial; and the third line, unmarked, indicates the divergences between the two.

Twelve comparisons were made, carrying 156 "difference figures." Naturally zeros and ones are all that can be desired, twos are quite satisfactory and indicate fair agreement, threes are somewhat wide, while fours and larger figures mean serious differences. All figures larger than three are shown in black face.

Reference number; changes in rations	Couples used, i. e., couple numbers, see table, page	Number of observations or records	Total dry matter eaten	Dry matter in grain feed	Quantity of milk	Total solids, percent	Fat, percent	Quantity of total solids	Quantity of fat	Products per 100 pounds of dry matter					
										In total ration			In experimental feed		
										Milk	Total solids	Fat	Milk	Total solids	Fat
I 1-2	C1, D1, E1, F1, G1	5 3	−2 0 2	−2 −2 0	−9 −6 3	+2 0 2	+5 +1 4	−8 −6 2	−4 −5 1	−9 −6 3	−6 −6 0	−3 −5 2	−7 −4 3	−4 −3 1	−2 −3 1
II 2-1	S22	1 8	+1 +3 2	+2 +3 1	+7 +6 1	+1 0 1	+1 0 1	+8 +5 3	+7 +5 2	+6 +4 2	+8 +5 3	+6 +4 2	+4 +3 1	+6 +3 3	+6 +2 4
III 1-3	A3, C2, D2, E2. G2. N13, P13, R13	8 4	+1 0 1	−2 −3 1	−1 −3 2	0 +1 1	−2 −1 1	−2 −2 1	−4 −3 1	−3 −3 0	−2 −2 0	−4 −3 1	0 +1 1	0 +1 1	−2 0 2
IV 3-1	T23, V23	2 4	−2 +1 3	+1 +2 1	+3 −1 4	+1 0 1	+2 +1 1	+4 −1 5	+5 +1 4	+4 −2 6	+5 −2 7	+6 −1 7	+2 −3 5	+3 −3 6	+5 −2 7
V 1-4	B4, D4, I10, K10, M15, O15	6 6	−2 +2 4	−2 +1 3	−7 −1 6	+1 +1 0	+3 +1 2	−6 0 6	−5 0 5	−5 −3 2	−5 −3 2	−3 −2 1	−4 −2 2	−3 −1 2	−2 −1 1
VI 4-1	V25, W24, X25, Y26	4 6	+1 −1 2	+3 −1 4	+6 0 6	−1 +1 2	−2 0 2	+5 0 5	+4 0 4	+5 0 5	+5 +1 4	+3 +1 2	+3 0 3	+2 +1 1	0 +1 1
VII 1-5	A5, H11, L16	8 5	0 0 0	0 0 0	+7 +6 1	0 0 0	−2 −1 1	+6 +6 0	+5 +5 0	+7 +6 1	+7 +5 2	+5 +5 0	+8 +6 2	+6 +5 1	+5 +5 0
VIII 1-6	C7, E7, F7, L18, N19, O19, P19, Q19	8 5	0 −2 2	0 0 0	+4 +4 0	0 +1 1	0 +1 1	+4 +5 1	+4 +5 1	+4 +1 3	+5 +2 3	+4 +2 2	+4 +3 1	+4 +4 0	+4 +4 0
IX 1-7	A9, N20, P20, R20, Q20	5 4	0 0 0	−1 −2 1	−9 −1 8	−1 −1 0	−2 −2 0	−9 −2 7	−9 −3 6	−7 −1 6	−8 −2 6	−10 −4 6	−6 0 6	−7 −1 6	−10 −2 8
X 7-1	BB29, CC28	2 4	−2 +4 6	+2 +5 3	−2 −1 1	+1 +1 0	+5 +2 3	−1 0 1	+2 +1 1	−1 −4 3	+2 −3 5	+4 −2 6	−4 −5 1	−3 −4 1	+1 −4 5
XI 6-7	Z31	1 4	−1 +3 4	0 +2 2	−7 −3 4	−1 −2 1	−1 −2 1	−9 −4 5	−8 −5 3	−5 −6 1	−7 −8 1	−6 −8 2	−6 −4 2	−8 −6 2	−7 −6 1
XII 7-6	AA30	1 5	−2 0 2	−3 0 3	+1 +1 0	+2 +1 1	+5 +1 4	+3 +2 1	+5 +2 3	+3 +1 2	+5 +3 2	+7 +2 5	+3 +1 2	+5 +2 3	+7 +2 5

There appear 58 "differences" which are threes or larger, including 18 threes, 11 fours and 29 fives or larger figures. Expressing the relation by way of fractions:

Three-eighths of the entire number are threes and larger;

One-fourth of the entire number are fours or larger;

One-fifth of the entire number are fives or larger.

The outcome of only three of the twelve sets is altogether satisfactory, being Nos. III, VII, VIII. Three of those which betray discrepancies show between them only 4 fours and a single five and are, therefore, not really bad comparisons. Another carries a single four and two fives, and, while bad, is not so very bad. Five (Nos. IV, V, VI, IX and X) are extremely unsatisfactory.

Good, III, VII, VIII,	3	Poor, XII,	1
Fair, I, II, XI,	3	Bad, IV, V, VI, IX, X,	5

How does the general results compare with those hitherto obtained?

	Good to fair	Indifferent	Bad	Number of comparisons
1901	Two-thirds		one-third	4
1902	One-half	one-sixth	one-third	7
1903	Two-fifths	one-fourth	one-third	15
1904	Three-fifths	one-sixth	one-fourth	17
1905	One-half	one-twelfth	two-fifths	12

The data available this year seemed on the whole better in quality and was larger in volume than any previous year save 1904. So far as could be foreseen and provided for, the pathway was made smooth for a successful issue. The herd was never in as good a condition for the purpose, no accidents of any account occurred, and little sickness was experienced. Yet the outcome was never more unsatisfactory. The same lot of excuses and apologies, of reasons and causes, may be and are offered. They are of the same general nature year after year. Condensing them to the briefest possible compass, this year's batch are:

I. *3 threes and a four.*—One record of one cow contributes four of the five records. An abnormally heavy milk shrinkage (Elizabeth, second period) and rise in fat percentage with a coincident slightly lowered quality in the milk of four of the five uniformly fed cows are at fault.

II. *3 threes and a four.*—A 5 to 8 percent shrinkage on uniform feeding (Eva, third period, the only available data) naturally distorts the result.

XI. *A three, 2 fours and a five.*—The result of equivalent irregularities in the single record used, that of the uniformly fed cow (Laura, second period).

XII. *3 threes, a four and 2 fives.*—Four of the five records used on the alternation side are plus records. Judith's is one of the larger of these. When linked with a minus record (Janice and Judith, second period) the differences are emphasized.

As for the bad records:

IV. *A three and 9 fours to sevens.*—An absurdity occurs here. Zirconia's second period record is compared with those made by Zeta and Una. Una, uniformly fed, shrank 10 percent in the third period. When this is compared with Zirconia's 4 percent shrinkage, we have the anomoly of a calculated 6 percent gain on a feed on which actually there occurred a 4 percent shrinkage. If V23 is rejected and T23 used alone, a good agreement is obtained.

V. *A three, a four, a five and two sixes.*—Stephanie shrank greatly during the second period, and Epsilon yet more in the third. These episodes offset each other when used according to the alternation scheme. Whether used or not the outcome is identical. Epsilon's record could not be matched, however, for use in the combined scheme. Hence Stephanie's record, contributing twice in the six records used, causes abnormal results. If excluded, good agreement is obtained. The 4 and the 3 in the dry matter data are caused by Epsilon's dainty eating in the third period. If her record is thrown out on the alternation side, agreement is attained.

VI. *A three, 3 fours, 2 fives and a six.*—Stephanie and Yttria made large plus records on passing from No. 4 to No. 1; Epsilon and Lady Perusia minus ones, which, moreover, in two cases were abnormally heavy, the former figure on both, the latter on one side of the comparison. Hence the discrepancies. If the Epsilon and Lady Perusia records are withdrawn from the alternation data, agreement is ideal.

IX. *6 sixes, a seven and 2 eights.*—Four of the five records on the alternation side are furnished by one cow, Alta, and by one comparison, her third and fifth period compared with her fourth. She made less milk in the fourth than in any other period, the minuses ranging from 8 to 11, whereas the other records used on the alternation side are pluses or small minuses. To use such a record four times in five with those of uniformly fed cows, which, moreover, tend on the whole to accentuate the differences, is to play havoc with hopes of agreement.

X. *3 threes, 2 fives and 2 sixes.*—This discrepancy is due to Adelaide's dainty eating during the first period, when she left uneaten a third of her hay, a quarter of her grain feed and a tenth of her silage, yet did not lessen her milk flow proportionately.

On which side of the fence does the fault lie? Is the alternation or the combined method at fault, or are neither credible? The writer's judgment is that the alternation data is the less trustworthy in Nos. VI and X, the combined less to be credited in Nos. I, II, IV, IX and XI, and that both are at fault in No. V.

The writer has become thoroughly convinced in his own mind as to the relative trustworthiness of the two methods. The outcome of these repeated trials serves but to confirm his views. The combined method is decidedly inferior to that of simple alternation and far more likely to afford erroneous results. But the testimony of both is better than that of either alone, even if at times confusing. Quoting the statement at the close of the article in the last report, the "accuracy of the result is enhanced and one's faith therein increased if the two methods are essentially a unit in its declaration. When, however, they disagree, . . . as a rule the alternation data is apt to be more reliable." It is unlikely that material change in this position will result from future trials. Yet it is expected to continue this comparison with a view of accumulating further data, less on that account, however, than for the good of the regular feeding trials, since, as has been remarked, the attainment of agreeing results by radically different methods of experimentation lends weight to the deductions which may be drawn therefrom. It is not likely, however, that more than a page or two of space will be given in future reports to the further discussion of what may be deemed to be a closed case.

A TRIAL OF THE HEGELUND OR DANISH METHOD OF MILKING

JOSEPH L. HILLS

A trial of the so-called Hegelund or Danish method of milking was carried out during the winter and spring with a view of studying its merits.[1] Parallel with it a test of extra-thorough stripping was made. The Hegelund manipulations were devised by the veterinarian of the Ladelund Dairy School, Denmark, and published by the Royal Agricultural Society of Denmark in 1900.[2] Their use is being widely advocated in that country. Sondergaard[3] has also suggested a system of udder massage or manipulation closely resembling that proposed by Hegelund. The latter method has undergone review in the hands of Woll[4] and Wing and Foord[5] in this country.

The manipulations, three in number, have been often described and are meant in general to imitate the movements of the udder produced by the calf. In brief it involves the ordinary practice of milking, followed by a series of hand manipulations; first, of the right quarters, together and upwards, and then of the left quarters similarly; second, of the fore quarters, together and upwards, and then the hind quarters

[1]Thesis investigation of Mr. V. A. Bates of the class of 1905, carried out under direction of the writer.

[2]Beretn. Landoekon. Konsulentvirksomhed, pp. 31-39 (1900).

[3]Den ny Malkemetode (1901).

[4]Wis. Sta. Bul. 96 (1902); also Pa. Dept. Agr. Bul. 113, pp. 17-55 (1903).

[5]N. Y. Cornell Sta. Bul. 213 (1903).

similarly; third, of the fore quarters thrust upwards from below and then of the hind quarters. Each manipulation of each set of quarters is repeated several times and the milk drawn until no more is obtained before the next set is entered upon. The full details with illustrations are given in several of the publications cited.

Seven cows were used in this trial, four mature and three heifers. They were uniformly fed hay, silage, bran, cottonseed and linseed meals (mixed feed No. 1). Only one cow, a heifer, was fresh; three were three to four months in milk; two, six months; and one seven months at the beginning of the trial, December 20. None of them were ready to dry off within two months of its close, April 4, or May 8; and all but one gave milk for five or more months later than that date. The test periods were three or four in number and were five weeks each in duration.

Minta Bella.—Calved May 9, '04; drying August 1, '05; ordinary milking five weeks, Dec. 20—Jan. 24; Hegelund treatment ten weeks, Jan. 24—April 4; ordinary milking five weeks, April 4—May 8.

Grace.—Calved Dec. 13, '04; ordinary milking five weeks, Dec. 20—Jan. 24; stripping ten weeks, Jan. 24—April 4; ordinary milking five weeks, April 4—May 8.

Valentine.—Calved Aug. 21, '04; same as Grace.

Haidee.—Calved June 17, '04; ordinary milking, five weeks, Dec. 20—Jan. 24; Hegelund treatment, five weeks, Jan. 24—Feb. 28; ordinary milking five weeks, Feb. 28—April 4.

Irene.—Calved Sept. 14, '04; same as Haidee.

Lizzie Hexham.—Calved June 28, '04; drying mid-June, '05; ordinary milking as with Haidee; stripping treatment five weeks, Jan. 24—Feb. 28.

Sheila.—Calved Aug. 9, '04; same as Lizzie Hexham.

These cows were treated in all respects as to feeding, weights of milk, sampling, etc., like those in the feeding experiments. Their feeding records appear with those of the other cows in the appendix and are summarized later on in this article. The residual milks were drawn into pails other than those in which the ordinary milk was received and were separately weighed and sampled. The results of the trials may be expressed as follows, the mean of the extreme (ordinary milking) priods being compared with the result obtained in the intermediate period—special manipulation. The records made during the initial twelve days in each period are rejected. It was intended to use eight cows, but one scheduled for the longer period of Danish treatment became unavailable.

The young man in whose charge the milking of the cows was placed was a cleaner milker than the average. He was charged in no

way to alter his usual procedure or to strive to milk more thoroughly. He understood the nature of the trial, knew that it was not meant to be a test of his ability or conscientiousness as a milker, gave it every attention and is thought to have carried out the instructions to the letter.

Period numbers	Days	Ordinary milk: Milk	Ordinary milk: Total solids	Ordinary milk: Fat	Ordinary milk: Total solids	Ordinary milk: Fat	Residual milk or strippings: Milk	Residual milk or strippings: Total solids	Residual milk or strippings: Fat	Residual milk or strippings: Total solids	Residual milk or strippings: Fat
		lbs.	%	%	lbs.	lbs.	lbs.	%	%	lbs.	lbs.
					MINTA BELLA						
I & IV,	46	566.9	15.80	6.27	89.49	35.55	....	.....	....	....	....
II & III,	46	546.0	15.85	6.22	86.56	33.93	52.8	17.12	7.95	9.04	4.20
					HAIDEE						
I & III,	23	382.1	15.88	5.69	60.68	21.75	....	.....	....	....	....
II,	23	365.3	15.85	5.58	57.89	20.37	19.3	18.65	8.76	3.60	1.69
					IRENE						
I & III,	23	447.5	13.40	4.32	59.95	19.32	....	.....	....	....	....
II,	23	440.6	13.35	4.09	58.80	18.01	25.5	16.63	7.73	4.24	1.97
					GRACE						
I & IV,	46	882.6	14.13	4.61	124.75	40.72	....	....	.....	....	....
II & III,	46	837.2	13.92	4.41	116.53	36.94	45.7	16.67	8.16	7.62	3.73
					VALENTINE						
I & IV,	46	561.2	15.79	5.98	88.62	33.58	....	.....	....	....	....
II & III,	46	515.2	15.45	5.64	79.58	29.05	42.2	19.69	10.55	8.31	4.45
					LIZZIE HEXHAM						
I & III,	23	427.0	14.44	4.71	61.65	20.11	....	.....	....	....	....
II,	23	430.9	14.05	4.45	60.57	19.19	33.9	17.82	8.88	6.04	3.01
					SHEILA						
I & III,	23	308.9	15.49	5.74	47.86	17.73	....	.....	....	....	....
II,	23	285.7	15.69	5.70	44.82	16.29	24.4	18.03	8.40	4.40	2.05

The above table, taken together with the one on the opposite page, shows for the three cows milked residually by the Hegelund method:

1. Less milk, total solids and fat in the ordinary milking when the residual milking was to follow, than was found when it was not to be carried out; also a slight tendency toward lower quality; *but*

2. More milk, total solids and fat in the ordinary milking and the residual milking together than in the usual product of the comparison period; also a very slight tendency toward better quality.

They show for the four cows which were extra stripped after the ordinary milking was completed:

1. Less milk, total solids and fat in the ordinary milking when the extra stripping was to follow, than was found when the supple-

Period numbers	Days	Milk	Total solids	Fat	Total solids	Fat
SUMMARY OF OUTCOME—HEGELUND MANIPULATIONS						
		lbs.	%	%	lbs.	lbs.
MINTA BELLA						
Usual,	46	566.9	15.80	6.27	89.49	35.55
do. + residuary,	46	598.8	15.97	6.37	95.60	38.13
HAIDEE						
Usual,	23	382.1	15.88	5.69	60.68	21.75
do. + residuary,	23	384.6	15.99	5.74	61.49	22.06
IRENE						
Usual,	23	447.5	13.40	4.32	59.95	19.32
do. + residuary,	23	466.1	13.53	4.29	63.04	19.98
SUMMARY OF OUTCOME—STRIPPING MANIPULATIONS						
GRACE						
Usual,	46	882.6	14.13	4.61	124.75	40.72
do. + strippings,	46	882.9	14.05	4.61	124.15	40.67
VALENTINE						
Usual,	46	561.2	15.79	5.98	88.62	33.38
do. + strippings,	46	557.4	15.77	5.84	87.89	32.55
LIZZIE HEXHAM						
Usual,	23	427.0	14.44	4.71	61.65	20.11
do. + strippings,	23	464.8	14.33	4.78	66.61	22.20
SHEILA						
Usual,	23	308.9	15.49	5.74	47.86	17.73
do. + strippings,	23	310.1	15.87	5.91	49.22	18.34

mentary procedure was not to be carried out; also a tendency toward lower quality.

2. Gain in milk, total solids and fat in but a single case when the extra strippings were added.

A consolidation of the data furnishes the following table:

	Milk lbs.	Total solids lbs.	Fat lbs.
Ordinary, 92 days,	1,397	210.1	76.6
do. plus residual, 92 days,	1,450	220.1	80.2
Gain,	53	10.0	3.6
Percent gain,	4	5	5
Ordinary, 138 days,	2,180	322.9	111.9
do. plus extra stripping, 138 days,	2,215	327.9	113.8
Gain,	35	5.0	1.9
Percent gain,	2	2	2

The amounts of residual milk, total solids and fat, lessened as the trial progressed when the Hegelund method was used, the average daily yields being:

	Minta Bella			*Haidee*			*Irene*		
	Milk	Solids	Fat	Milk	Solids	Fat	Milk	Solids	Fat
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
First 12 days,	1.7	0.29	0.14	0.9	0.18	0.08	1.5	0.19	0.09
Next 23 days,	1.3	0.22	0.10	0.8	0.16	0.07	1.1	0.18	0.09
Nexxt 12 days,	1.1	0.18	0.09						
Next 23 days,	1.0	0.17	0.08						

It was as if the cows realized that they must and so "gave down" more at the first milking. The same result was obtained with Grace when stripped.

FOOD CONSUMPTION

The cows invariably ate more dry matter and more of the several nutrients during the time they were residually milked or were extra stripped than they did during the other periods. This was due mainly to the fact that the silage then fed was slightly more mature than that used at other times. These differences are brought out in the accompanying table. The three residually milked cows, when thus treated, ate 4 percent more dry matter, 6 percent more digestible dry matter, 3 percent more protein and 7 percent more carbohydrates; while the four which were extra stripped ate 3 percent more dry matter, 5 percent more digestible dry matter, 3 percent more protein and 5 to 6 percent more carbohydrates. This increase in food consumption is in the same direction as and closely equivalent to the increase in milk and butter yield. This obviously introduces an element of doubt into the case and leads one to question how much of the gain in yield is due to the special udder manipulations and how much to added food consumption.

Name of cow		Total dry matter	Digestible dry matter	Digestible protein	Digestible crude fiber	Digestible nitrogen-free extract	Digestible ether extract	Nutritive ratio
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	1 :
Minta Bella	Ordinary,	968.0	601.9	97.3	126.2	325.2	26.3	5.3
	Residual,	1014.2	640.3	101.6	137.8	345.1	28.5	5.4
	Excess residual over ordinary,	+46.2	+38.4	+4.3	+11.6	+19.9	+2.2	
	Percentage excess,	+ 5	+ 6	+ 5	+ 9	+ 6	+8	
Haidee	Ordinary,	505.5	313.9	49.9	67.1	169.4	13.5	5.4
	Residual,	524.3	333.1	51.4	71.5	181.4	14.8	5.6
	Excess residual over ordinary,	+18.7	+19.8	+1.5	+ 4.4	+12.0	+1.3	
	Percentage excess,	+ 4	+ 6	+ 3	+ 7	+ 7	+1.0	
Irene	Ordinary,	515.5	319.3	50.5	68.7	171.8	13.7	5.4
	Residue,	526.4	334.1	51.5	71.7	181.8	14.8	5.6
	Excess residual over ordinary,	+10.9	+14.8	+1.0	+ 3.0	+10.0	+1.1	
	Percentage excess,	+2	+ 5	+ 2	+ 4	+ 6	+ 8	
Grace	Ordinary,	939.3	585.3	95.7	121.7	316.2	25.9	5.2
	Stripping,	965.1	616.3	99.6	130.8	332.3	27.9	5.3
	Excess stripping over ordinary,	+25.8	+31.0	+3.9	+ 9.1	+16.1	+2.0	
	Percentage excess,	+ 3	+ 5	+ 4	+ 8	+ 5	+ 8	
Valentine	Ordinary,	869.5	539.8	79.7	125.4	288.5	21.7	5.8
	Stripping,	894.4	565.1	82.3	134.0	301.6	23.0	6.0
	Excess stripping over ordinary,	+24.9	+25.3	+2.6	+ 8.6	+13.1	+1.3	
	Percentage excess,	+ 3	+ 5	+ 3	+ 7	+ 5	+ 6	
L. Hexham	Ordinary,	468.8	292.0	47.5	62.0	157.1	12.9	5.3
	Stripping,	485.4	308.8	49.4	64.8	167.9	14.2	5.4
	Excess stripping over ordinary,	+16.6	+16.8	+1.9	+ 2.4	+10.8	+1.3	
	Percentage excess,	+ 4	+ 5	+ 4	+ 4	+ 7	+1.0	
Sheila	Ordinary,	506.0	314.2	49.9	67.1	169.4	13.5	5.4
	Stripping,	507.5	322.9	50.6	68.5	175.9	14.6	5.5
	Excess stripping over ordinary,	+ 1.5	+ 8.7	+0.7	+ 1.4	+ 6.5	+1.1	
	Percentage excess,	+ 3	+ 3	+ 1	+ 2	+ 4	+ 8	

The manipulations take from three to five minutes to each milking. This would be equivalent to from nine to fifteen hours in the 92 day test, and from fifteen to twenty-three hours in the 138 day one. The immediate returns—53 pounds of milk or four and a fifth pounds of butter—at best would hardly more than repay the cost of the extra labor involved in carrying out the Hegelund method; and the fifteen to twenty-three hours' work extra stripping for a return of two and one-fourth pounds of butter was done at a decided loss. If, as is probably the fact, the persistency of the milking habit and the more perfect development of the udder are encouraged by either procedure, its adoption has considerable justification, particularly with heifers. This phase of the matter, however, is not included within the scope of the present inquiry. On the other hand, the additional load of dirt, dandruff, hair, dried manure, bacteria, etc., which fall into the milking pail because of the udder manipulation, is a distinct detriment, which, however, the use of some of the covered pails would go far to obviate.

In the Wisconsin trials, which were far more extensive than those now under review, from 8 to 9 percent additional fat was obtained by the Hegelund process and 7 percent by extra stripping. In the Cornell trials, also in some respects of wider scope than the present ones, though conducted for brief periods only, from 7 to 9 percent additional fat was gained by the Hegelund method in two herds and 20 percent in another, where "a young woman," milking seven out of 18 cows in a single herd, left 28 percent of the available fat unmilked, while an "extra harvest hand" left over 40 percent in the udder. They further show almost as much gain from extra stripping as from the Danish manipulation.

Incomplete milking causes large losses, potentially as well as actually. Any scheme which serves to accentuate this loss, to bring it home more forcibly to the average milker, is well worth while. That any special virtue to this end is possessed by a given set of manipulations over thorough stripping, seems to the writer to be as yet unproven.

A COMPARISON OF UDDER CONFORMATION AND OF MILK PRODUCTION

Joseph L. Hills

The conformation of the udder, its approximation in outline to the curve of a semi-circle, its extension therefrom, its balance of quarters, etc., are justly regarded as all important in the judging of a dairy cow. A poorly balanced udder, or one lacking depth, one which is deficient in the fore quarters or is funnel-shaped, or not well carried up behind, is not deemed a perfect milk making mechanism. Is this proposition borne out in fact? Do cows with ill-balanced udders make materially less milk and butter than those whose glands are better proportioned?

The mature animals of the station herd which had made one or more years of record were carefully surveyed and grouped into three lots; those with well-balanced udders, those with fairly well-balanced udders, and those whose udders were deficient, usually in the fore quarters. The groupings were made by Mr. Bates,[1] who was essentially uninformed as to the records of the animals which he had under observation. The outcome is shown herewith. Every record of each cow now in the herd was used except single ones made in first lactation, two where abortion seriously affected yield, one where continuous low feeding lowered production, and one incomplete one.

Name	Years	Milk	Butter	Name	Years	Milk	Butter	Name	Years	Milk	Butter
Inez,	6	5567	369	Ceres,	7	6574	414	Eva,	6	5489	413
Edith,	4	5574	335	Haidee,	6	5544	361	Minta Bella,	8	5851	399
Fresno,	2	6197	309	Lady Perusia	6	5248	366	Star Bright,	6	4829	323
Ursula,	2	5521	340	Pomona,	7	6002	379	Adelaide,	4	5094	310
Alta,	1	5766	357	Mona,	4	6282	370	Lavender,	4	4939	323
				Hallowe'en,	4	5136	319	Mermaid,	4	5661	396
				Lucerne,	4	5328	341	Santa Rosa,	3	5153	273
				Rosel,	4	7075	386	Vivian,	2	5214	281
				Santa Clara,	3	4771	332	Constance,	1	4460	263
				Sonoma,	3	6288	370	Lizzie H.,	1	5749	302
				Una,	3	4188	279	Yemassee,	1	4968	280
				Elsa,	2	4403	272				
				Janice,	2	4023	241				
				Md. Marion,	2	5889	327				
				Surprise,	2	4271	287				
				Yuba,	2	4765	292				
				Judith,	1	5068	345				
				Stephanie,	1	5952	320				
5 cows,	3.	5725	342	18 cows,	3.5	5377	333	11 cows,	3.6	5219	324

[1]This study, in addition to the review of the Hegelund method, was involved in the thesis presentation referred to in the footnote [1] on page 412.

The cows were viewed two or three times independently in order to make the more certain that errors in grouping were not made. The only doubt as to this matter is as to the placing of Mona and Pomona which, perhaps, should be found in a lower class. Their records are large enough to affect the results materially, as will be seen on reference to the three lines of average data below, wherein these records are counted in the second class in the first line, in the third class in the second, and discarded entire in the third line. Indeed, the average butter yield of the third class is decidedly increased by the presence therein of three of the best cows in the herd, which ranked second, third and fourth in the entire herd in butter production in a series of years ranging from three to nine.

	Milk	Butter		Milk	Butter		Milk	Butter
Well balanced,	5725	342	Fairly so,	5377	333	Poorly so,	5219	324
" "	5725	342	"	5281	328	"	5361	332
" "	5725	342	"	5281	328	"	5219	324

The result is not strongly indicative one way or the other, but its tendency is to bear out the score card finding. Four out of five cows with well-balanced udders made more butter than did the average of the eighteen which had but fairly well-balanced udders or the eleven with poorly-balanced udders. They also made more than the average of the herd for twelve years, 324 pounds. Per contra, eight out of the eleven cows with poorly-balanced udders made less butter than did the average of the five whose udders were well built or the eighteen whose glands were fairly well-formed; and their records were all, moreover, below the twelve year herd average of 324 pounds.

MILK FROM FORE AND HIND QUARTERS

A study of the relative quantities and qualities of the milk yield of the fore and hind quarters of the udder was made, using five cows, all fairly fresh in milk, all fed hay, silage, bran, cottonseed and linseed meals (mixed feed No. 1). Three of the cows—Marigold, Euclina and Dolly—had rather poorly-formed udders, the fore quarters being somewhat less developed than the hind ones; the other two—Gray Beauty and Maid Marion—carried fairly well-balanced udders. The milk from the fore quarters was drawn separately from that produced by the hind quarters and separately weighed, sampled and analyzed. The trial was conducted during ten weeks from mid-March to late May. During the first half of this time the milk from the fore quarters was drawn first, during the second half that from the hind quarters. In all other respects uniformity was observed so far as was practicable. The data given below cover the last twenty-three days of each thirty-five day period.

There was no difference in the general outcome whether the fore and hind quarters were milked first. Forty-six percent of the yield of milk, total solids and fat were produced by the fore quarters, and 54 percent by the hind ones. Quality was practically identical in each case. The three cows with rather deficient fore quarters made less milk therein each period. Gray Beauty, possessing a well-balanced udder, yielded decidedly more from the fore quarters; and Maid Marion, also blessed with a well-formed gland, made but little more from one than the other, but that little was made by the hind quarters. If Gray Beauty's record is omitted, the proportions become 43 and 57 percents of the total product yielded by the front and by the hind quarters respectively.

A trial reported by Beach[1] of three milkings of fifteen cows showed an average of 41 percent yield from the front and 59 percent from the rear udder.

Name	FORE QUARTERS					HIND QUARTERS				
	Milk	Total solids	Fat	Total solids	Fat	Milk	Total solids	Fat	Total solids	Fat
FIRST 23 DAYS. FORE QUARTERS MILKED FIRST										
Marigold,	249.6	13.10	4.04	32.69	10.08	354.7	13.17	4.06	46.71	14.41
Euclina,	295.5	13.17	4.14	38.90	12.22	336.6	13.04	3.93	43.88	13.22
G. Beauty,	357.1	13.92	4.71	49.69	16.83	267.8	13.72	4.53	36.73	12.12
Dolly,	143.4	14.78	5.35	21.20	7.67	239.0	14.62	5.18	34.95	12.39
M.Marian,	304.4	13.22	4.24	40.24	12.90	354.8	12.70	3.83	45.04	13.57
Totals,	1350.0	13.53	4.42	182.72	59.70	155.29	13.35	4.23	207.31	65.71
SECOND 23 DAYS. HIND QUARTERS MILKED FIRST										
Marigold,	226.1	13.28	4.13	30.03	9.33	343.5	13.18	4.08	45.26	14.00
Euclina,	254.8	13.15	4.10	33.52	10.45	326.4	13.17	4.08	42.99	13.33
G.Beauty,	324.1	13.72	4.59	44.45	14.87	255.4	13.75	4.61	35.12	11.77
Dolly,	133.7	14.87	5.38	19.88	7.19	241.7	14.94	5.42	36.11	13.10
M. Marian,	275.0	12.90	4.05	35.48	11.15	277.0	12.64	3.92	35.00	10.85
Totals,	1213.7	13.46	4.37	163.36	52.99	1444.0	13.47	4.37	194.48	63.05

[1]Conn. (Storrs) Sta. Rpt., 16, pp. 131-4 (1904).

RECORD OF THE STATION HERD FOR 1904-5

JOSEPH L. HILLS

As a matter of record and without comment such as has been annually made for many years, the following data is printed. The general statements hitherto made as to details hold for this record as in the past, to which such as may be interested in analyzing this matter are referred. At the present time (December, 1905) the collation of the data thus derived and published for many years past, is under way with a view of special publication in the not distant future.

RECORD OF THE HERD OF THE VERMONT AGRICULTURAL EXPERIMENT STATION FOR THE YEAR FROM NOV. 1, 1904, TO OCT. 31, 1905[1]

Name	Age	Calved 1904	Calved 1905	Served 1904 or 1905
Adelaide,	11	Sept. 29	Farrow	....
Alta,	7	Aug. 7	Farrow	Nov. 19
Cassandra,	5	Sept. 1	Dec., late	....
Ceres,	14	Jan. 9	May 18	July 29
Chi,	9	Sept. 1	....	April 23
Constance,	5	Aug. 10	June 27	Nov. 18
Edith,	7	April 28	July 12	Dec. 16
Elizabeth,	4	Nov. 13	Nov. 26	....
Elsa,	8	Nov. 11	Farrow	Nov. 8
Epsilon,	4	Sept. 1	....	May 26
Eva,	12	Nov. 23	Farrow	Dec. 20
Fatima,	3	Sept. 4	Oct. 29	....
Francis,	8	Sept. 1	March 26	Nov. 25
Fresno,	6	Dec. 29	Nov. 30	....
Gamma,	7	Sept. 11	Nov. 4	....
Haidee,	8	June 17	Farrow	Sept. 22
Hallowe'en,	11	Dec. 24, '03	May 21	Aug. 7
Inez,	12	Dec. 23	....	June 4
Irene,	9	Sept. 14	Farrow	Nov. 27
Janice,	9	Aug. 18	Nov. 25	....
Judith,	8	April 25	Dec. 20	....
LADY PERUSIA,	11	Feb. 15	Farrow	May 24
Laura,	5	Sept. 16	Oct. 14*	....
Lavender,	7	Sept. 10	Dec. 12	....
Lizzie Hexham,	5	June 28	Aug. 15	Nov. 5
Lucerne,	11	Nov. 2	....	June 27
Maid Marion,	13	Jan. 2	March 4	Nov. 12
Mermaid,	9	Aug. 16	Sept. 12	....
MINTA BELLA,	13	May 9	Sept. 11	Dec. 8
Mona,	8	Jan. 13	May 11	Oct. 6
Mu,	5	Sept. 18	....	June 10
Myrtle,	4	Oct. 11	Oct. 19	....
Pomona,	13	Dec. 23, '03	Aug. 8	....
Rebecca,	8	Sept. 19	Farrow	Dec. 5
Rosel,	7	Sept. 2	Sept. 15	....
Santa Clara,	6	Dec. 14	Dec. 31	....
Santa Rosa,	6	Nov. 7	Oct. 20	....
Serena,	8	Feb. 15	March 28	Oct. 25
Sheila,	4	Aug. 9	....	April 10
Sonoma,	6	Jan. 13	May 9	....
Stella,	7	Dec. 3, '03	March 29	Nov. 20
Stephanie,	8	Aug. 22	....	April 13
UNA (VT.),	5	Oct. 31	Nov. 6	....
Ursula,	9	*Oct. 30	....	June 26
Valentine,	3	Aug. 22	Sept. 9	Nov. 15
Vivian,	9	Nov. 2	....	June 5
Yemassee,	10	Sept. 17	Farrow	....
Yttria,	8	Sept. 22	Farrow	....
Yuba,	6	Nov. 28	....	May 8
Zeta,	7	Sept. 25	....	June 20
Zillah,	4	Aug. 3	Oct. 28	....
Zirconia,	8	Oct. 4	....	June 20

[1]Names in capitals, registered Jerseys; in italics, Ayrshire; remainder, grade Jerseys. *Aborted.

RECORD OF THE HERD OF THE VERMONT AGRICULTURAL EXPERIMENT STATION FOR THE YEAR FROM NOV. 1, 1904, to OCT. 31, 1905

Name of cow	Days in milk	Milk, lbs.	Total solids, percent	Fat, percent	Total solids, lbs.	Fat, lbs.	Butter, lbs.
Adelaide,	363	4160	14.60	5.34	607.4	222.2	259.3
Alta,	365	5964	14.89	5.39	888.0	321.2	374.8
Cassandra,	365	5741	15.23	5.45	874.2	312.6	364.7
Ceres,	305	5253	14.40	5.14	756.6	270.2	315.3
Chi,	365	4488	15.01	5.51	673.8	247.1	288.3
Constance,	347	4210	15.20	5.73	640.0	241.0	281.2
Edith,	332	5860	14.43	5.06	845.7	296.3	345.7
Elizabeth,	274	3590	15.68	5.94	562.9	213.3	248.9
Elsa,	355	7760	14.38	5.12	1115.8	396.9	463.1
Epsilon,	365	3188	15.28	5.54	487.0	176.7	206.2
Eva,	342	4817	15.16	5.64	730.1	271.8	317.1
Fatima,	353	3627	16.36	6.50	593.8	235.9	275.2
Francis,	328	6401	14.03	4.58	897.8	293.2	342.1
Fresno,	319	5468	13.63	4.47	745.5	244.3	285.0
Gamma,	315	5257	15.86	6.03	833.9	317.0	369.9
Haidee,	365	5063	15.54	5.62	786.8	284.4	331.8
Hallowe'en,	303	3866	14.16	5.02	547.5	194.0	226.4
Inez,	323	5971	14.61	5.36	872.6	320.3	373.7
Irene,	365	6061	13.31	4.33	806.9	262.2	305.9
Janice,	315	3555	14.86	5.12	528.1	182.0	212.4
Judith,	362	4117	16.07	6.37	661.7	262.1	305.8
LADY PERUSIA,	365	3933	16.50	6.62	649.0	260.3	303.7
Laura,	365	5656	14.55	5.08	822.6	287.3	335.2
Lavender,	341	4401	14.94	5.54	657.6	243.8	284.5
Lizzie Hexham,	312	5815	14.05	4.50	817.1	261.4	305.0
Lucerne,	363	4468	15.46	5.82	690.8	259.8	303.1
Maid Marian,	316	5406	13.37	4.51	722.9	243.6	284.2
Mermaid,	334	5479	15.63	5.85	856.4	320.6	374.0
MINTA BELLA,	318	3770	15.37	5.90	579.4	222.6	259.7
Mona,	312	5606	14.01	4.81	785.3	269.8	314.8
Mu,	365	6221	14.68	5.29	913.2	328.8	383.6
Myrtle,	332	5256	15.60	5.76	820.2	302.6	353.0
Pomona,	310	3901	14.32	5.17	558.4	201.5	235.1
Rebecca,	365	7843	14.58	5.11	1143.7	401.0	467.9
Rosel,	330	5622	14.31	4.77	804.4	268.4	313.1
Santa Clara,	320	6422	14.88	5.47	955.7	351.2	409.7
Santa Rosa,	328	5598	14.05	4.65	786.6	260.2	303.6
Serena,	319	5885	13.92	4.62	819.4	271.7	317.0
Sheila,	365	4454	15.53	5.82	691.8	259.2	302.4
Sonoma,	341	5321	14.60	5.12	776.8	272.5	317.9
Stella,	327	5031	13.92	4.62	700.2	232.1	270.8
Stephanie,	365	7048	14.06	4.62	990.7	325.8	380.1
UNA (VT.),	322	5353	15.03	5.71	804.3	305.8	356.8
Ursula,	365	5400	14.73	5.34	795.5	288.3	336.4
Valentine,	320	4146	15.49	5.73	642.3	237.4	277.0
Vivian,	353	6960	13.72	4.47	954.9	310.9	362.7
Yemassee,	365	6751	14.18	4.83	957.0	325.8	380.1
Yttria,	365	7330	14.61	5.15	1070.5	377.7	440.7
Yuba,	337	6710	14.22	5.00	954.0	335.6	391.5
Zeta,	365	6068	14.55	4.88	882.6	295.8	345.1
Zillah,	334	5702	13.73	4.36	783.0	248.8	290.3
Zirconia,	365	5937	14.26	4.81	846.5	285.8	333.4
Average,	341	5343	14.73	5.25	782.5	277.4	323.6

RECORD OF THE HERD OF THE VERMONT AGRICULTURAL EXPERIMENT STATION FOR THE YEAR FROM NOV. 1, 1904, to OCT. 31, 1905

Name of cow	Cost of food	Cost of grain	Cost of food for 100 lbs. milk, cts.	Cost of food for 1 lb. fat, cts.	Cost of food for 1 lb. butter, cts.	Butter at 30 cents a pound	Value of manurial ingredients
Adelaide,	$58.39	$27.35	140.3	26.5	22.5	$77.79	$31.32
Aita,	61.58	28.64	103.3	19.2	16.4	112.44	33.33
Cassandra,	61.08	28.98	106.4	19.5	16.8	109.41	33.38
Ceres,	55.35	22.82	105.4	20.5	17.6	94.59	29.31
Chi,	62.34	28.78	138.9	25.3	21.6	86.49	33.58
Constance,	54.56	26.56	129.6	22.6	19.4	84.36	30.06
Edith,	59.73	27.36	101.9	20.2	17.3	103.71	31.64
Elizabeth,	50.96	23.55	142.0	23.9	20.5	74.67	25.74
Elsa,	61.37	27.54	79.1	15.9	13.3	138.93	36.91
Epsilon,	58.17	25.83	182.5	32.9	28.2	61.86	30.46
Eva,	61.16	27.34	127.0	22.5	19.3	95.13	29.01
Fatima,	57.36	26.09	158.2	24.3	20.9	82.56	30.89
Francis,	56.90	24.38	88.9	19.4	16.6	102.63	30.71
Fresno,	55.66	22.81	101.8	22.8	19.5	85.50	26.67
Gamma,	56.13	25.84	106.8	17.7	15.2	110.97	30.84
Haidee,	61.93	28.21	122.6	21.8	18.7	99.42	33.93
Hallowe'en,	53.89	22.47	139.4	27.8	23.8	67.92	27.48
Inez,	57.74	23.63	96.7	18.1	15.5	112.11	29.67
Irene,	62.37	28.93	102.8	23.8	20.4	91.77	34.18
Janice,	54.73	26.05	154.0	30.1	25.8	63.72	29.00
Judith,	59.70	27.40	145.0	22.8	19.5	91.74	32.71
LADY PERUSIA,	61.56	28.48	156.5	23.7	20.3	91.11	31.87
Laura,	61.74	28.55	109.2	21.5	18.4	98.31	34.47
Lavender,	58.97	27.03	134.0	24.2	20.8	85.35	32.20
Lizzie Hexham,	57.23	26.01	98.4	21.9	18.8	91.50	31.06
Lucerne,	61.08	27.97	136.7	23.5	20.2	90.93	32.97
Maid Marian,	53.10	20.73	98.0	21.8	18.7	85.26	28.33
Mermaid,	57.39	26.14	104.7	17.9	15.3	112.20	31.27
MINTA BELLA,	54.54	25.93	144.7	24.5	21.0	77.91	29.45
Mona,	54.60	23.16	97.4	20.2	17.3	94.44	31.00
Mu,	62.98	29.06	101.3	19.2	16.4	115.08	33.31
Myrtle,	58.61	26.81	111.6	19.4	16.6	105.90	31.31
Pomona,	53.69	24.83	137.7	26.7	22.8	70.53	29.61
Rebecca,	61.41	28.03	78.3	15.3	13.1	140.37	30.51
Rosel,	56.79	26.15	101.3	21.2	18.1	93.93	30.87
Santa Clara,	58.23	24.98	90.7	16.6	14.2	122.91	30.42
Santa Rosa,	56.11	24.66	100.2	21.6	18.6	91.08	27.36
Serena,	54.82	22.76	93.1	20.2	17.3	95.10	29.78
Sheila,	60.13	29.20	135.0	23.2	19.9	90.72	32.75
Sonoma,	57.35	25.40	107.8	21.0	18.0	95.37	30.21
Stella,	54.75	23.48	108.8	23.6	20.2	81.24	30.11
Stephanie,	61.96	29.17	87.9	19.0	16.3	114.03	32.72
UNA (VT.),	56.65	26.86	105.8	18.5	15.6	107.04	28.61
Ursula,	67.06	33.85	124.2	23.3	19.9	100.92	35.69
Valentine,	54.17	25.54	130.7	22.8	19.6	83.10	29.31
Vivian,	61.91	29.06	89.0	19.9	17.1	108.81	33.84
Yemassee,	62.19	29.07	92.1	19.1	16.4	114.03	34.01
Yttria,	61.93	28.30	84.5	16.4	14.1	132.21	32.08
Yuba,	58.01	24.40	86.5	17.3	14.8	117.45	31.63
Zeta,	53.64	28.88	88.4	18.1	15.6	103.53	30.26
Zillah,	56.15	25.53	98.5	22.6	19.3	87.09	30.46
Zirconia,	62.12	29.90	104.6	21.7	18.6	100.02	32.97
Averages,	58.31	26.65	113.6	21.6	18.5	96.93	31.18

RECORD OF THE HERD OF THE VERMONT AGRICULTURAL EXPERIMENT STATION FOR THE YEAR FROM NOV. 1, 1904, to OCT. 31, 1905

Name	Age	Calved 1904	Calved 1905	Served 1904 or 1905
Ardelle,		....	April 11	Sept. 29
Dolly,		....	Winter	Nov. 4
Euclina,		....	*Winter	....
Grace,		Dec. 13	....	Aug. 4
Gray Beauty,		....	Winter	Nov. 9
Hazel K.,		....	April 26	Oct. 20
Lanta,		....	May 25	Nov. 8
Marigold,		....	Winter	July 5
Nancy B.,	17	Oct. 25	....	Sold
Sabra,		....	March 17	Aug. 12
Sarnia,	6	Sept. 20	....	Sold
Star Bright,	8	Aug. 24	....	Sold
Surprise,	5	Farrow	....	Sold
Thoria,	6	Sept. 22	....	Sold

Name of cow	Days in milk	Milk, lbs.	Total solids, percent	Fat, percent	Total solids, lbs.	Fat, lbs.	Butter, lbs.
Ardelle,	205	2587	13.92	5.31	360.2	137.4	160.3
Dolly,	239	3416	15.18	5.67	518.5	193.6	225.9
Euclina,	239	5140	13.39	4.29	688.5	220.4	257.2
Grace,	323	5056	14.32	4.85	723.8	245.2	286.1
Gray Beauty,	239	5278	13.96	4.78	737.2	252.4	294.5
Hazel K.,	190	2796	14.99	4.81	419.0	134.6	157.0
Lanta,	159	3234	12.52	3.53	404.8	114.3	133.3
Marigold,	239	4271	13.05	4.14	557.3	177.0	206.5
Nancy B.,	126	2725	12.62	3.79	343.8	103.2	120.4
Sabra,	218	1835	15.29	5.75	280.6	105.5	123.1
Sarnia,	210	2722	14.25	4.74	387.8	129.0	150.5
Star Bright,	232	3479	15.39	5.66	535.3	196.8	229.6
Surprise,	287	1918	17.13	6.91	328.5	132.6	154.7
Thoria,	126	2296	14.94	5.30	342.9	121.7	142.0

Name of cow	Cost of food	Cost of grain	Cost of food for 100 lbs. milk, cts.	Cost of food for 1 lb. fat, cts.	Cost of food for 1 lb. butter, cts.	Butter at 30 cents a pound	Value of manurial ingredients
Ardelle,	$25.25	$10.13	97.6	18.3	15.8	$48.09	$12.02
Dolly,	35.62	16.25	104.3	18.3	15.8	67.77	18.29
Euclina,	37.96	16.32	73.9	17.2	14.8	77.16	19.50
Grace,	47.13	19.67	93.3	19.2	16.5	85.83	25.16
Gray Beauty,	37.09	16.32	70.3	14.7	12.6	88.35	18.94
Hazel K.,	23.99	8.93	85.7	17.8	15.3	47.10	11.41
Lanta,	20.48	6.86	63.4	18.0	15.4	39.99	8.90
Marigold,	35.54	16.32	80.9	20.1	17.2	61.95	18.14
Nancy B.,	27.20	18.28	99.8	26.5	22.7	36.12	15.97
Sabra,	29.21	12.32	159.4	27.8	23.7	36.93	14.04
Sarnia,	41.93	21.96	154.0	32.5	27.9	45.15	23.96
Star Bright,	42.75	21.94	122.8	21.7	18.6	68.88	25.19
Surprise,	46.63	24.70	243.1	35.2	29.6	46.41	27.37
Thoria,	23.90	12.20	104.1	19.6	16.8	42.60	14.66

FEEDING RECORD

Name of cow	Hay	Oat hay	Barn grass hay	Grass	Corn silage	Pomace silage	Wheat bran	Cottonseed meal	Linseed meal	Corn meal	Hominy feed	India wheat
Adelaide,	2670	207	55	516	6782	416	1472	255	328	155	...	9
Alta,	2708	251	88	503	7684	416	1548	298	316	155	...	9
Ardelle,	1325	13	...	342	1939	...	553	138	76	62	...	...
Cassandra,	2714	219	112	646	6986	416	1565	373	255	155	...	9
Ceres,	3208	235	117	644	5517	484	1233	264	98	155	...	103
Chi,	2777	230	117	645	7749	354	1369	353	254	157	186	9
Constance,	2556	138	59	646	5247	399	1439	457	133	141	...	...
Dolly,	1747	68	...	628	2894	...	883	232	114	99	...	...
Edith,	2666	210	110	640	7374	416	1251	354	226	142	...	182
Elizabeth,	2154	229	109	20	6373	353	1243	203	150	81	...	197
Elsa,	2821	233	110	646	7745	416	1996	516	94	136	...	9
Epsilon,	2632	223	104	640	7070	380	1457	263	128	143	184	8
Euclina,	1894	70	...	642	3909	...	886	223	114	100	...	9
Eva,	2870	231	108	646	7677	281	1429	121	...	126	...	474
Fatima,	2692	201	95	646	6644	380	1210	346	231	120	186	9
Francis,	3053	242	80	648	6133	484	1328	314	149	155	42	9
Fresno,	2891	218	145	646	6801	416	1192	102	...	94	...	402
Gamma,	2402	223	107	400	7068	416	1397	447	138	112	...	9
Grace,	2306	166	35	642	5980	...	1073	268	165	97	...	6
Gray Beauty,	1805	70	...	641	3620	...	886	210	126	100	...	9
Haidee,	2786	253	98	646	7712	484	1525	386	232	144	...	9
Hallowe'en,	3097	205	71	636	5452	416	1205	212	55	162	...	180
Hazel K.,	1399	15	...	386	1621	...	484	121	75	47	...	...
Inez,	3010	264	65	643	7005	880	1257	230	94	103	...	205
Irene,	2760	237	98	645	7673	484	1572	397	233	155	...	...
Janice,	2272	210	102	398	6493	416	1391	123	460	111	...	9
Judith,	2735	224	71	503	7323	416	1481	416	188	137	...	9
Lady Perusia,	2711	207	106	640	7718	416	1570	265	94	148	276	9
Lanta,	1225	18	...	475	1118	...	367	93	76	17	...	...
Laura,	2760	194	104	646	7672	416	1554	626	...	154	...	9
Lavender,	2611	244	87	509	7367	416	1458	369	232	127	...	9
Lizzie Hexham,	2495	164	85	472	7535	484	1400	355	233	112	...	9
Lucerne,	2689	256	90	636	7713	416	1288	380	227	82	267	9
Maid Marian,	2936	265	94	642	5025	2386	1165	188	199	149	...	...
Marigold,	1745	64	...	636	2817	...	886	223	114	100	...	...

FEEDING RECORD

Name of cow	Hay	Oat hay	Barn grass hay	Grass	Corn silage	Pomace silage	Wheat bran	Cottonseed meal	Linseed meal	Corn meal	Hominy feed	India wheat
Mermaid,	2403	262	96	263	7755	416	1409	357	232	114	...	9
Minta Bella,	2196	193	77	222	6983	484	1398	353	229	115	...	9
Mona,	2934	240	92	648	5765	486	1260	359	116	152	...	9
Mu,	2813	240	120	643	7779	416	1572	397	232	155	...	9
Myrtle,	2510	225	111	399	7691	416	1443	136	461	123	...	9
Nancy B.,	517	39	37	...	3631	490	986	249	173	74	...	...
Pomona,	2385	116	34	492	6675	416	1355	565	...	115	...	...
Rebecca,	2769	219	116	643	7648	416	1568	157	...	162	463	9
Rosel,	2292	240	81	341	7763	416	1402	365	232	112	...	9
Santa Clara,	1541	15	...	346	2400	...	646	162	74	88	...	...
Sabra,	2901	202	56	641	7220	668	1113	302	202	109	...	224
Santa Rosa,	2564	208	85	587	7218	416	1381	102	...	125	463	9
Sarnia,	1620	168	90	...	6772	416	710	281	227	62	450	7
Serena,	3017	214	90	639	4737	2430	1246	312	153	149	...	...
Sheila,	2615	192	65	638	6744	484	1578	399	237	153	...	9
Sonoma,	2907	214	105	646	6283	416	1164	327	171	162	...	183
Star Bright,	1765	155	101	...	6850	416	1171	202	320	60	...	9
Stella,	3030	246	83	507	5521	484	1280	410	72	155	...	9
Stephanie,	2672	206	112	639	7643	415	1570	296	186	148	186	9
Surprise,	1909	227	86	98	6117	484	1329	336	232	95	...	9
Thoria,	928	136	93	...	3617	484	665	280	...	55	...	...
Una,	2494	213	107	588	6303	373	933	323	212	114	...	434
Ursula,	2759	213	105	515	7756	416	1251	449	276	172	552	9
Valentine,	2219	183	84	275	6875	484	1360	355	230	117	...	8
Vivian,	2749	211	109	318	7741	414	1572	397	232	155	...	9
Yemassee,	2708	218	112	646	7691	416	1572	398	232	155	...	9
Yttria,	2785	230	116	616	7763	416	1561	253	96	162	269	9
Yuba,	2935	242	55	645	7373	416	1314	301	252	100	...	9
Zeta,	2791	270	77	513	7023	416	1117	225	225	162	...	466
Zillah,	2452	212	102	642	6941	416	1374	308	268	109	...	9
Zirconia,	2732	269	75	644	6960	416	1386	388	231	162	...	195

APPENDIX CONTAINING
CONDENSED DATA REFERRING TO ARTICLE ON FEEDING TRIALS WITH COWS

JOSEPH L. HILLS

I. Weights of cows.

II. Average barn temperatures, with ranges and percentages of uniformity.

III. Analyses and digestible ingredients in fodders and feeds; (*a*) analyses on dry basis; (*b*) digestion coefficients; (*c*) pounds of digestible nutrients in 100 pounds of original substance.

IV. Feeding records of the individual cows in feeding tests.

V. Production records; showing production and same per unit for each individual cow in feeding tests.

VI. Difference tables: (*a*) totals of differences; (*b*) percentage differences.

VII. Results of experimental feeding on different rations.

I. WEIGHTS OF COWS

	Elizabeth	Inez	Hallowe'en	Eva	Fresno	Zirconia	Santa Clara	Edith	Sonoma	Zeta	Vt. Una
I*	776	...	921	815	...	840	...	820	915	813	743
I†	788	798	940	850	900	820	823	831	916	791	741
II†	805	808	958	860	876	815	808	850	969	804	728
III†	808	821	976	875	888	838	806	878	975	805	743
IV†	837	813	...	903	893	832	800	913	...	817	770
V†	832	775	...	860	872	882	805	945	...	830	802

	Stephanie	Yttria	Epsilon	Lady Perusia	Santa Rosa	Rebecca	Chi	Lucerne	Fatima	Sarnia	Ursula
I*	813	730	720	988	878	813	856	843	795	930	991
I†	821	743	731	998	866	820	846	855	811	971	998
II†	796	775	763	1055	861	832	900	865	825	966	1011
III†	841	771	703	1040	893	831	888	878	841	953	1055
IV†	837	793	757	1115	900	850	923	830	826	980	1080
V†	837	787	775	1137	941	852	935	875	855	1005	1041

	Constance	Elsa	Gamma	Lavender	Vivian	Laura	Cassandra	Alta	Adelaide	Star Bright	Yemassee
I*	760	936	838	925	823	875	785	835	906	931	896
I†	734	944	808	925	841	883	812	842	832	925	946
II†	760	943	834	950	843	883	796	848	870	960	941
III†	761	918	841	955	856	913	763	858	853	993	936
IV†	785	937	863	955	880	945	823	848	860	1007	920
V†	757	883	875	940	853	985	802	880	791	980	892

	Mu	Mermaid	Rosel	Janice	Judith	Yuba	Zillah	Pomona	Myrtle
I*	808	818	981	875	850	950	823	855	781
I†	830	830	1003	878	838	935	825	813	798
II†	840	828	990	910	862	946	823	830	796
III†	858	836	985	930	848	965	841	863	821
IV†	870	857	1010	935	845	980	860	885	820
V†	840	822	1005	930	850	967	780	882	785

*Beginning. †End.

II. AVERAGE BARN TEMPERATURES, WITH RANGES AND PERCENTAGES OF UNIFORMITY

Period number		Average temperature			Range of temperature			Percent of whole within 3° F. of mean		
		5 A.M.	12 M.	6 P.M.	5 A.M.	12 M.	6 P.M.	5 A.M.	12 M.	6 P.M.
MAIN BARN										
I.	Pre.	48	47	48	47-52	43-48	47-50	83	83	100
	Exp.	51	47	50	42-62	39-55	44-56	61	65	65
II.	Pre.	50	46	50	41-56	38-50	42-53	43	83	92
	Exp.	47	46	49	40-56	38-52	42-55	65	57	74
III.	Pre.	49	45	48	42-56	40-51	40-55	57	75	42
	Exp.	51	49	51	47-54	42-56	43-57	91	78	73
IV.	Pre.	59	53	56	53-63	47-62	52-68	75	57	83
	Exp.	58	55	57	53-62	47-65	52-62	65	70	57
V.	Pre.	59	59	60	56-63	53-66	56-70	75	42	57
	Exp.	62	63	66	54-71	54-74	58-75	44	57	39
ANNEX BARN										
I.	Pre.	44	43	44	41-49	40-48	42-47	83	83	100
	Exp.	51	50	51	40-60	34-58	37-58	44	35	35
II.	Pre.	51	52	53	44-60	44-58	40-58	50	57	57
	Exp.	48	48	49	42-58	35-55	38-56	52	61	61
III.	Pre.	51	50	52	44-58	46-59	46-57	50	83	75
	Exp.	52	55	53	45-58	51-62	48-58	52	65	83
IV.	Pre.	60	59	59	52-65	48-72	55-72	50	57	83
	Exp.	58	60	60	51-62	45-65	55-65	70	57	79
V.	Pre.	58	65	63	51-62	60-72	59-71	50	75	42
	Exp.	63	68	68	54-76	56-76	60-74	61	39	44

III. ANALYSES AND DIGESTIBLE INGREDIENTS IN FODDERS AND FEEDS

(*a*) ANALYSES ON DRY BASIS; (*b*) DIGESTION COEFFICIENTS; (*c*) POUNDS OF DIGESTIBLE NUTRIENTS IN 100 POUNDS OF ORIGINAL SUBSTANCE

(*a*) ANALYSES ON DRY BASIS

Fodders and feeds	Dates of sampling	Original substance		Composition of dry matter							
		Water	Dry matter	Crude ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Nitrogen	Phosphoric acid	Potash
Hay, main barn,	Dec.-Feb.	17.09	82.91	7.43	9.37	31.62	49.04	2.54	1.50	0.55	1.55
“ “ “	Mar.-May	13.53	86.47	7.63	9.94	30.35	49.37	2.71	1.59	0.55	1.58
Hay, annex barn,	Dec.-Feb.	16.13	83.87	7.22	9.13	34.34	47.03	2.28	1.46	0.50	2.39
“ “ “	Mar.-May	12.21	87.79	6.92	9.25	32.99	48.46	2.38	1.48	0.52	2.08
Barn grass hay,	Dec.	22.63	77.37	15.53	11.31	36.53	35.44	1.19	1.81	0.59	6.09
Oat hay,	Dec.	17.18	82.82	11.32	11.31	33.38	41.83	2.16	1.81	0.78	3.96
Oat hay,	Jan.	16.34	83.66	10.48	10.31	35.27	41.75	2.19	1.65	0.77	3.95
Silage,	Dec.-Jan.	80.49	19.51	7.05	10.50	26.98	53.29	2.18	1.68	0.61	1.86
“	Jan.-Feb.	79.63	20.37	6.64	9.76	25.21	56.51	1.88	1.56	0.65	1.88
“	Feb.-Mar.	79.11	20.89	6.63	8.94	27.09	55.09	2.25	1.43	0.66	1.28
“	Mar.-Apr.	81.21	18.79	7.13	10.25	29.45	51.26	1.91	1.64	0.65	1.86
“	Apr.-May	80.97	19.03	7.30	9.87	29.65	51.64	1.54	1.58	0.55	1.61
Mixed feed No. 1,	Dec.-Feb.	11.60	88.40	6.66	23.06	10.82	52.91	6.55	3.69	2.66	1.55
“ “ “	Mar.-May	10.85	89.15	6.38	24.56	9.90	52.30	6.86	3.93	2.57	1.68
“ “ No.2,	Dec.-Feb.	14.35	85.65	5.59	15.00	6.75	68.35	4.31	2.40	2.27	1.29
“ “ “	Mar.-May	11.72	88.28	6.08	15.19	7.76	66.06	4.91	2.43	2.26	1.40
“ “ No.3,	Dec.-Feb.	13.44	86.56	5.48	21.81	7.63	59.27	5.81	3.49	1.85	1.33
“ “ “	Mar.-May	11.72	88.28	5.91	22.50	8.00	57.12	6.47	3.60	1.99	1.39
“ “ No.4,	Dec.-Feb.	12.00	88.00	5.54	14.50	8.18	65.93	5.85	2.32	2.34	1.28
“ “ “	Mar.-May	11.81	88.19	5.89	14.25	8.75	65.32	5.79	2.28	2.29	1.41
“ “ No.5,	Dec.-Feb.	12.45	87.55	5.59	22.25	8.10	56.76	7.30	3.56	1.94	1.39
“ “ “	Mar.-May	11.12	88.88	5.62	22.00	8.02	56.63	7.73	3.52	1.99	1.39
“ “ No.6,	Dec.-Feb.	11.85	88.15	6.87	24.38	11.74	49.94	7.07	3.90	2.82	1.80
“ “ “	Mar.-May	10.60	89.40	7.02	24.00	10.34	51.23	7.41	3.84	2.82	1.89
“ “ No.7,	Dec.-Feb.	12.07	87.93	6.61	23.54	10.14	53.98	5.73	3.76	2.13	1.66
“ “ “	Mar.-May	10.98	89.02	6.55	22.69	10.84	54.14	5.78	3.63	2.24	1.71
Wheat bran,	Dec.-Feb.	12.44	87.56	6.73	15.38	9.65	63.48	4.76	2.46	2.95	1.62
“ “	Mar.-May	11.44	88.56	6.86	15.25	10.80	62.03	5.06	2.44	2.92	1.73
Cottonseed meal,	Dec.-Feb.	9.86	90.14	6.58	40.56	11.60	30.42	10.84	6.49	2.17	1.92
“ “	Mar.-May	8.20	91.80	7.06	44.56	10.25	26.86	11.27	7.13	2.83	2.01
Linseed meal,	Dec.-Feb.	11.34	88.66	6.27	35.00	9.36	41.83	7.54	5.60	1.70	1.36
“ “	Mar.-May	10.49	89.51	5.93	36.25	9.56	40.60	7.66	5.80	1.70	1.36
India wheat meal,	Dec.-Feb.	16.40	83.60	3.90	13.44	1.45	78.93	2.28	2.15	0.90	0.54
“ “ “	Mar.-May	14.41	85.59	4.25	14.37	1.69	76.46	3.23	2.30	0.80	0.45
Hominy feed,	Dec.-Feb.	11.60	88.40	2.37	11.50	3.37	76.30	6.46	1.84	0.92	1.90
“ “	Mar.-May	10.57	89.43	2.61	11.44	3.94	74.93	7.08	1.83	1.06	2.07

(b) DIGESTION COEFFICIENTS*; (c) POUNDS OF DIGESTIBLE NUTRIENTS IN 100 POUNDS OF ORIGINAL SUBSTANCE

Fodders and feeds	Dates	Digestion coefficients					Digestible nutrients					Nutritive ratio, 1:
		Dry matter	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract	Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	
Hay,† main barn,	Dec.-Feb.	60	57	58	64	57	49.7	4.4	15.2	26.0	1.2	10.0
" " "	Mch.-May	..	..	..	..	..	51.9	4.9	15.2	27.3	1.8	9.3
Hay, annex barn,	Dec.-Feb.	..	..	..	..	..	50.3	4.4	16.7	25.2	1.1	10.1
" " "	Mch.-May	..	..	..	..	..	52.7	4.6	16.8	27.2	1.2	10.2
Barn grass hay,	Dec.	49	54	44	52	62	37.9	4.7	12.4	14.3	0.6	6.0
Oat hay,	Dec.	49	54	44	52	62	40.6	5.1	12.2	18.0	1.1	6.4
" "	Jan.	..	..	..	..	..	41.0	4.7	13.0	18.2	1.1	7.2
Corn silage,	Dec.-Jan.	66	51	71	67	80	12.9	1.10	3.7	7.0	0.3	10.4
" "	Jan.-Feb.	..	..	..	..	..	13.4	1.00	3.6	7.7	0.3	12.0
" "	Feb.-Mch.	..	..	..	..	..	13.8	0.95	4.0	7.7	0.4	13.3
" "	Mch.-Apr.	..	..	..	..	..	12.4	0.98	3.9	6.5	0.3	11.4
" "	Apr.-May	..	..	..	..	..	12.6	0.96	4.0	6.6	0.2	11.6
Mixed feed No. 1‡,	Dec.-Feb.	67	83	39	71	78	59.2	16.9	3.7	33.2	4.5	2.8
" " "	Mch.-May	..	..	..	..	..	59.7	18.2	3.4	33.1	4.8	2.6
" " No. 2‡,	Dec.-Feb.	65	78	26	69	70	55.7	10.0	1.5	40.4	2.6	4.8
" " "	Mch.-May	..	..	..	..	..	57.4	10.5	1.8	40.2	3.0	4.6
" " No. 3‡,	Dec.-Feb.	70	84	30	69	84	60.6	15.9	2.4	35.4	4.2	3.0
" " "	Mch.-May	..	..	..	..	..	61.8	16.7	2.5	34.8	4.8	2.9
" " No. 4‡,	Dec.-Feb.	71	78	37	79	75	62.5	10.0	2.7	45.8	3.9	5.7
" " "	Mch.-May	..	..	..	..	..	62.6	9.8	2.9	45.5	3.8	5.8
" " No. 5‡,	Dec.-Feb.	76	84	48	81	83	66.5	16.4	3.4	40.2	5.3	3.4
" " "	Mch.-May	..	..	..	..	..	67.6	16.4	3.4	40.8	5.7	3.5
" " No. 6‡,	Dec.-Feb.	66	84	39	67	81	58.2	18.1	4.0	29.5	5.0	2.5
" " "	Mch.-May	..	..	..	..	..	59.0	18.1	3.6	30.7	5.3	2.5
" " No. 7‡,	Dec.-Feb.	68	84	38	71	78	59.8	17.4	3.4	33.7	3.9	2.6
" " "	Mch.-May	..	..	..	..	..	60.5	17.0	3.7	34.2	4.0	2.8
Wheat bran,	Dec.-Feb.	62	78	29	69	68	54.3	10.5	2.5	38.4	2.8	4.5
" "	Mch.-May	..	..	..	..	..	54.9	10.5	2.8	37.9	3.1	4.5
Cottonseed meal,	Dec.-Feb.	74	88	56	61	93	66.7	32.2	5.9	16.7	9.1	1.3
" "	Mch.-May	..	..	..	..	..	67.9	36.0	5.3	15.0	9.6	1.2
Linseed meal,	Dec.-Feb.	79	89	57	78	89	70.0	27.6	4.7	28.9	6.0	1.7
" "	Mch.-May	..	..	..	..	..	70.7	28.9	4.9	28.3	6.1	1.6
India wheat§,	Dec.-Feb.	70	77	..	68	79	58.5	8.7	...	44.9	1.5	5.6
" "	Mch.-May	..	..	..	..	..	59.9	9.5	...	44.5	2.2	5.2
Hominy feed,	Dec.-Feb.	90	77	82	95	81	79.6	7.8	2.4	64.1	4.6	9.8
" "	Mch.-May	..	..	..	..	..	80.5	7.9	2.9	63.7	5.1	9.9

*From tables of digestibility of American feeding stuffs; Jordan and Hall, Bul. 77, Office Exp. Sta. U. S. Dept. Agr. (1900).

†Assumed to be two-thirds timothy in bloom and one-third red clover; perhaps a somewhat high assumption as regards clover.

‡Calculated from analyses of their ingredients and from digestion coefficients of the same.

§Assumed same as buckwheat, the digestion coefficients for which were calculated from the statement in Henry (Feeds and Feeding), who appears to have drawn the data from Dietrich and Koenig's Zusammensetzung der Futtermittel.

IV. FEEDING RECORDS OF INDIVIDUAL COWS

Period numbers	Name of cow Number of ration	Pounds eaten of: Hay	Oat hay	Barn grass hay	Silage	Wheat bran	½ cottonseed meal ½ linseed meal	India wheat meal	½ cottonseed meal ½ corn meal	Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period: Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	Nutritive ratio, 1:
ELIZABETH																	
I.	No. 1,	60	..	55	368	63	19	..	14	250.5	84.6	158.4	23.4	31.9	87.7	6.3	5.7
		115	48	54	688	122	62	..	..	485.1	162.8	294.9	48.5	62.5	155.6	12.6	5.1
II.	No. 2,	60	49	..	360	64	2	30	..	249.9	83.0	151.7	18.5	30.1	90.6	4.9	7.1
		160	61	..	688	122	..	62	..	485.9	157.5	299.2	35.2	59.9	180.2	9.3	7.4
III.	No. 1,	117	..	..	360	64	30	2	..	261.2	84.5	164.3	24.4	35.5	90.4	7.1	5.8
		222	..	..	689	122	62	..	..	503.7	163.2	320.1	50.6	67.7	174.1	14.5	5.4
IV.	No. 2,	114	..	..	360	64	2	30	..	251.9	85.4	158.7	19.5	33.1	92.7	5.5	7.1
		220	..	..	684	122	..	62	..	491.0	161.7	303.9	36.6	63.4	178.6	10.3	7.2
V.	No. 1,	117	..	..	353	64	30	2	..	259.9	86.6	162.3	25.9	35.2	87.1	6.7	5.3
		204	..	..	684	122	62	..	..	478.2	163.6	301.9	49.7	64.8	161.2	12.9	5.1
INEZ																	
II.	No. 1,	60	41	..	375	64	30	2	..	248.6	85.2	153.4	24.1	31.4	84.3	6.6	5.4
		164	61	..	780	122	62	..	..	513.1	161.6	319.7	49.0	67.4	174.6	13.3	5.6
III.	No. 2,	118	..	..	408	64	2	30	..	270.5	82.3	168.5	19.1	35.8	100.5	5.6	7.8
		227	..	..	780	122	..	62	..	524.2	159.7	330.3	37.6	69.0	196.1	11.4	7.7
IV.	No. 1,	117	..	..	405	64	30	2	..	264.4	86.6	168.0	26.5	36.9	90.1	7.2	5.4
		225	..	..	781	122	62	..	..	516.8	163.6	323.5	51.8	71.1	172.6	14.0	5.2
V.	No. 2,	119	..	..	407	64	2	30	..	272.0	86.1	168.0	20.1	36.2	97.6	5.3	7.3
		214	..	..	772	122	..	62	..	502.1	161.2	313.3	37.0	66.7	183.4	9.6	7.3
HALLOWE'EN																	
I.	No. 2,	40	36	29	398	63	..	19	14	248.0	83.5	155.6	19.4	30.9	91.3	5.3	6.9
		115	37	42	770	122	..	62	..	478.8	158.2	290.7	35.7	60.6	170.1	8.9	7.0
II.	No. 1,	60	27	..	406	64	30	2	..	243.1	85.2	152.2	23.8	31.4	83.6	6.5	5.5
		142	36	..	776	121	62	..	..	478.3	160.7	298.4	46.7	62.9	163.0	12.5	5.4
III.	No. 2,	101	..	..	398	61	2	29	..	251.7	78.8	157.1	17.8	34.4	92.9	5.2	7.8
		196	..	..	763	116	..	59	..	482.8	151.9	308.4	34.5	66.6	182.4	10.6	7.9
EVA																	
I.	No. 2,	60	..	53	400	63	..	19	14	254.3	83.5	159.8	19.7	31.7	93.8	5.3	7.0
		115	48	55	782	122	..	62	..	500.9	158.2	301.1	36.9	62.3	175.7	9.2	7.0
II.	No. 2,	60	52	..	404	64	..	32	..	261.4	82.8	158.7	18.6	31.9	95.1	4.9	7.4
		163	60	..	781	122	..	62	..	507.5	157.5	312.8	36.2	63.6	187.9	9.6	7.5
III.	No. 2,	115	..	..	408	64	..	32	..	267.8	82.1	167.0	18.6	35.3	100.2	5.4	7.9
		226	..	..	781	122	..	62	..	523.7	159.7	330.0	37.6	68.9	195.8	11.3	7.7
IV.	No. 2,	118	..	..	407	64	..	32	..	264.4	85.3	166.4	19.8	35.5	97.3	5.5	7.3
		226	..	..	780	122	..	62	..	515.6	161.7	318.9	37.8	68.1	186.4	10.5	7.4
V.	No. 2,	118	..	..	407	64	..	32	..	271.1	86.1	167.2	19.7	35.9	97.7	5.1	7.4
		205	..	..	777	122	..	62	..	495.2	161.2	309.2	36.6	65.6	181.3	9.6	7.3

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow / Number of ration	Pounds eaten of: Hay	Oat hay	Barn grass hay	Silage	Wheat bran	½ cottonseed meal ½ linseed meal	India wheat meal	½ cottonseed meal ½ corn meal	Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period: Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	Nutritive ratio, 1:
FRESNO																	
II.	No. 2,	60	47	..	406	64	..	32	..	257.8	82.8	157.0	18.5	31.3	94.4	4.8	7.4
		159	61	..	779	122	..	62	..	502.8	157.5	310.9	36.1	63.0	186.9	9.5	7.5
III.	No. 2,	118	..	..	406	64	..	32	..	269.8	82.1	168.1	18.7	35.6	100.9	5.4	8.0
		216	..	..	787	115	..	57	..	497.2	149.3	313.2	35.6	65.8	185.6	10.8	7.7
IV.	No. 2,	116	..	..	406	64	..	32	..	262.5	85.3	165.2	19.7	35.1	96.7	5.5	7.3
		223	..	..	776	122	..	62	..	512.1	161.7	316.8	37.6	67.5	185.3	10.5	7.4
V.	No. 2,	118	..	..	400	64	..	32	..	269.7	86.1	166.3	19.6	35.6	97.2	5.1	7.4
		187	..	..	780	122	..	62	..	480.0	161.2	300.3	35.8	62.9	176.5	9.3	7.3
ZIRCONIA																	
I.	No. 1,	40	40	30	359	63	19	..	14	245.5	84.6	154.5	23.3	31.3	85.3	6.3	5.6
		115	48	45	681	122	62	..	..	476.4	162.8	291.2	48.0	62.8	152.9	12.4	5.1
II.	No. 3,	60	50	..	358	33	31	30	..	248.3	81.6	155.4	23.8	31.8	85.0	6.3	5.5
		162	62	..	675	62	61	61	..	493.9	159.2	308.7	46.4	64.1	169.2	12.0	5.6
III.	No. 1,	115	..	..	346	61	32	2	..	257.0	83.6	161.8	24.4	36.4	87.3	6.9	5.7
		219	..	..	668	122	62	..	..	492.8	163.2	317.4	49.6	69.9	171.4	14.1	5.5
IV.	No. 3,	98	..	..	353	34	32	30	..	238.4	85.7	154.4	24.4	32.8	82.9	6.7	5.4
		222	..	..	678	62	61	61	..	494.9	161.2	314.4	48.3	68.3	168.5	13.2	5.5
V.	No. 1,	110	..	..	358	62	32	2	..	259.5	86.6	160.5	25.7	36.2	85.1	6.6	5.3
		222	..	..	678	122	62	..	..	497.4	163.6	312.2	49.8	70.8	165.5	12.9	5.3
SANTA CLARA																	
II.	No. 1,	60	42	..	403	62	32	2	..	255.4	85.2	157.8	24.8	32.5	86.2	6.7	5.4
		153	54	..	780	122	62	..	..	498.3	161.6	311.3	48.1	64.9	170.5	13.0	5.5
III.	No. 3,	116	..	..	406	34	32	30	..	269.3	83.3	171.6	24.5	36.3	95.4	7.0	6.2
		221	..	..	780	62	61	61	..	521.1	161.7	335.6	49.7	69.4	184.4	14.5	5.8
IV.	No. 1,	115	..	..	403	62	32	2	..	262.4	86.7	167.1	26.8	36.6	89.2	7.3	5.3
		221	..	..	764	122	62	..	..	509.9	163.6	319.2	51.4	60.8	170.4	14.0	5.3
V.	No. 3,	117	..	..	400	34	32	30	..	268.8	86.0	170.1	25.9	36.3	91.6	6.7	5.5
		208	..	..	776	62	61	61	..	499.1	162.7	319.1	49.2	67.2	172.0	12.8	5.4
EDITH																	
I.	No. 1,	60	..	56	400	63	19	..	14	257.6	84.6	162.9	23.8	33.2	90.0	6.4	5.8
		115	47	54	774	121	62	..	..	501.4	162.0	305.0	49.2	65.5	161.2	12.7	5.2
II.	No. 3,	60	44	..	396	34	32	30	..	253.7	83.3	158.8	24.2	31.6	88.0	6.4	5.5
		162	61	..	715	58	58	57	..	485.4	149.6	306.0	45.1	62.5	169.5	11.8	5.7
III.	No. 1,	118	..	..	371	62	32	2	..	264.5	84.5	166.6	24.9	36.1	91.3	7.2	5.8
		224	..	..	767	122	62	..	..	522.4	163.2	331.9	51.4	71.1	180.7	14.8	5.5
IV.	No. 3,	118	..	..	403	34	32	30	..	264.0	85.7	170.2	26.2	36.1	91.7	7.1	5.5
		227	..	..	770	62	61	61	..	513.9	161.2	326.6	50.2	69.1	176.0	13.8	5.5
V.	No. 1,	118	..	..	402	62	32	2	..	270.6	86.6	169.3	26.9	37.4	90.3	6.9	5.3
		209	..	..	773	122	62	..	..	500.3	163.6	315.7	50.7	69.1	168.5	13.0	5.3

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow / Number of ration	Pounds eaten of: Hay	Oat hay	Barn grass hay	Silage	Wheat bran	½ cottonseed meal ½ linseed meal	India wheat meal †	½ cottonseed meal ½ corn meal	Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period: Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	Nutritive ratio, 1:
	SONOMA																
I.	No. 3,	60	..	53	400	44	19	19	14	254.8	84.0	162.6	23.2	32.3	90.8	6.2	5.9
		115	43	52	778	62	61	61	..	494.6	159.3	306.2	47.7	63.0	164.7	12.0	5.3
II.	No. 1,	60	48	..	407	62	32	2	..	261.2	85.2	157.2	24.1	33.2	85.5	6.5	5.5
		152	56	..	779	122	62	..	..	499.0	161.6	311.6	48.2	65.0	170.8	13.0	5.5
III.	No. 3,	112	..	..	401	33	31	30	..	263.1	81.6	167.7	23.9	35.4	93.2	6.8	6.0
		220	..	..	778	62	61	61	..	519.8	161.7	334.9	49.7	69.1	184.0	14.5	5.8
	ZETA																
I.	No. 3,	40	40	23	362	42	17	17	14	235.1	78.8	149.4	21.5	29.8	83.6	5.7	6.6
		115	47	54	686	61	61	61	..	479.6	158.5	296.8	46.9	62.0	158.1	11.7	5.3
II.	No. 3,	60	52	..	360	32	32	32	..	252.0	83.2	157.8	24.1	32.2	86.3	6.3	5.5
		162	61	..	687	61	61	61	..	494.8	158.3	309.3	46.4	64.3	169.3	12.1	5.6
III.	No. 3,	118	..	..	358	32	32	31	..	261.0	82.4	166.3	23.9	36.4	90.9	6.6	6.0
		223	..	..	687	62	61	61	..	498.8	161.7	325.6	48.3	69.6	177.6	14.0	5.7
IV.	No. 3,	106	..	..	356	32	32	32	..	245.8	85.6	159.1	24.8	34.1	85.3	6.8	5.4
		221	..	..	685	62	61	61	..	495.4	161.2	314.7	48.4	68.4	168.6	13.3	5.5
V.	No. 3,	114	..	..	356	32	32	32	..	262.2	86.0	164.1	25.0	35.8	87.9	6.5	5.5
		223	..	..	684	62	61	61	..	498.6	162.7	317.0	48.4	69.4	169.8	12.6	5.5
	VERMONT UNA																
I.	No. 3,	60	..	53	366	44	19	19	14	248.1	84.0	158.2	22.8	31.0	88.5	6.1	5.8
		115	47	46	680	61	61	61	..	471.9	158.5	292.3	46.5	59.1	157.5	11.7	5.2
II.	No. 3,	60	52	..	356	31	31	31	..	249.1	80.6	155.1	23.6	31.0	85.4	6.2	5.5
		160	62	..	686	62	31	31	..	488.0	159.2	308.1	46.4	61.7	170.8	12.2	5.6
III.	No. 3,	114	..	..	351	32	32	32	..	255.5	83.2	163.2	23.8	33.7	90.6	6.7	5.9
		217	..	..	685	62	61	61	..	497.0	161.7	320.4	48.6	65.0	175.9	14.0	5.6
IV.	No. 3,	110	..	..	358	32	32	32	..	248.4	85.6	160.6	25.3	33.1	86.7	6.9	5.4
		221	..	..	660	62	61	61	..	486.6	161.2	309.8	48.8	63.9	167.2	13.4	5.4
V.	No. 3,	117	..	..	350	32	32	32	..	258.7	86.0	163.9	25.5	34.2	88.4	6.6	5.4
		213	..	..	681	62	61	61	..	484.6	162.7	309.6	48.4	64.2	167.0	12.7	5.4
	STEPHANIE																
I.	No. 1,	60	..	57	400	63	19	..	14	258.3	84.6	163.3	23.9	33.4	90.2	6.4	5.8
		115	41	55	782	122	62	..	..	499.7	162.8	304.4	49.3	65.3	161.1	12.9	5.2
II.	No. 4,	60	49	..	404	64	2	30	..	260.8	84.7	163.9	18.7	32.5	99.4	6.0	7.8
		155	54	..	778	121	..	61	..	496.1	158.3	317.5	34.9	63.3	194.5	11.5	8.1
III.	No. 1,	105	..	..	401	64	30	2	..	260.2	84.5	164.5	24.2	35.4	90.9	7.2	5.9
		210	..	..	772	122	62	..	..	511.5	163.2	325.3	50.7	69.2	177.1	14.6	5.5
IV.	No. 4,	113	..	..	401	64	2	30	..	259.1	85.5	168.6	19.1	35.6	100.3	6.4	7.9
		207	..	..	743	121	..	61	..	491.0	161.1	314.2	35.1	65.8	188.5	11.8	8.0
V.	No. 1,	114	..	..	381	64	30	2	..	262.8	86.5	164.7	26.1	35.9	88.5	6.8	5.4
		190	..	..	757	122	62	..	..	480.5	163.6	303.8	49.7	65.6	162.3	12.8	5.2

†Hominy feed in Stephanie's case.

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow / Number of ration	Pounds eaten of										Pounds of digestible nutrients eaten during period					Nutritive ratio, 1:
		Hay	Oat hay	Barn grass hay	Silage	Wheat bran	½ cottonseed meal ½ linseed meal	Hominy feed	½ cottonseed meal ½ corn meal	Total dry matter in entire ration	Total dry matter in experimental feed	Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	
	YTTRIA																
I.	No. 4,	60	..	58	400	62	..	18	14	257.0	82.5	164.5	19.6	32.9	97.0	5.9	7.8
		115	48	58	782	122	..	62	..	506.6	161.4	315.2	36.6	64.6	187.0	11.4	7.6
II.	No. 1,	60	52	..	406	64	30	2	..	264.3	85.2	162.5	24.9	33.9	89.1	6.8	5.6
		162	61	..	781	122	62	..	..	511.7	161.6	318.9	48.9	67.2	174.4	13.2	5.6
III.	No. 4,	119	..	..	408	64	2	30	..	272.4	83.4	175.3	18.9	36.9	106.1	6.6	8.4
		223	..	..	779	118	..	59	..	516.3	155.4	334.7	35.5	70.2	202.3	12.7	8.5
IV.	No. 1,	116	..	..	408	64	30	2	..	264.2	86.6	168.3	26.5	36.9	90.5	7.2	5.4
		226	..	..	775	122	62	..	..	516.4	163.6	323.2	51.8	71.0	172.5	14.0	5.3
V.	No. 4,	117	..	..	408	64	2	30	..	270.0	85.6	172.4	19.3	36.9	102.2	6.0	7.9
		220	..	..	776	122	..	62	..	509.2	162.3	327.9	36.1	69.7	195.9	11.5	8.1
	EPSILON																
I.	No. 1,	60	..	54	360	63	19	..	14	248.1	84.6	156.7	23.3	31.6	86.4	6.3	5.7
		115	46	50	655	119	59	..	..	468.1	157.5	284.8	47.0	60.3	150.5	12.2	5.1
II.	No. 4,	60	48	..	352	61	2	29	..	245.6	81.2	154.1	17.7	30.4	93.3	5.8	7.7
		157	59	..	690	121	..	61	..	483.0	158.3	308.8	34.4	61.1	189.1	11.3	8.0
III.	No. 1,	108	..	..	283	59	27	2	..	229.9	77.5	145.1	22.0	30.9	79.9	6.3	5.7
		196	..	..	585	104	52	..	..	433.9	138.4	275.5	43.3	58.7	149.7	12.4	5.5
IV.	No. 4,	97	..	..	346	63	2	30	..	234.0	84.6	152.9	17.8	31.0	91.9	6.0	7.7
		213	..	..	662	120	..	60	..	478.1	159.3	306.0	34.4	63.4	183.9	11.6	8.5
V.	No. 1,	104	..	..	352	62	30	2	..	246.5	84.7	154.7	24.9	33.2	83.8	6.5	5.3
		190	..	..	667	122	62	..	..	462.6	163.6	292.5	48.8	62.0	156.3	12.6	5.1
	LADY PERUSIA																
I.	No. 4,	60	..	52	400	63	..	19	14	254.2	84.2	163.5	19.5	32.1	97.0	5.3	7.2
		115	40	54	781	121	..	62	..	495.5	160.5	309.6	36.0	63.1	184.5	11.1	7.6
II.	No. 1,	60	47	..	408	64	30	2	..	260.6	85.2	160.8	24.7	33.3	88.3	6.7	5.5
		158	53	..	780	122	62	..	..	501.5	161.6	313.4	48.4	65.5	171.7	13.1	5.5
III.	No. 4,	113	..	..	406	63	2	29	..	265.2	81.7	170.9	18.5	35.9	103.5	6.6	8.3
		213	..	..	779	122	..	62	..	513.9	161.6	333.9	35.6	68.9	202.7	12.9	8.4
IV.	No. 1,	113	..	..	401	64	30	2	..	260.2	86.6	165.8	26.2	36.2	89.2	7.2	5.4
		221	..	..	767	122	62	..	..	510.4	163.6	319.6	51.4	69.9	170.6	14.0	5.3
V.	No. 4,	116	..	..	390	64	2	30	..	265.5	85.6	169.6	19.1	36.0	100.8	6.0	7.9
		198	..	..	772	122	..	62	..	489.2	162.3	316.0	34.9	66.3	189.7	11.1	8.1
	SANTA ROSA																
I.	No. 4,	60	..	39	399	63	..	19	14	244.4	84.2	158.5	18.8	30.4	95.2	5.2	7.3
		115	41	46	778	122	..	62	..	490.2	161.4	307.2	35.8	62.3	183.9	11.3	7.6
II.	No. 4,	60	43	..	404	63	..	31	..	255.1	82.9	160.4	17.8	31.6	98.1	5.9	8.0
		156	56	..	779	121	..	62	..	499.8	159.2	319.6	35.2	63.8	195.7	11.5	8.1
III.	No. 4,	115	..	..	405	64	..	32	..	268.3	83.3	173.3	18.4	36.2	105.6	6.6	8.5
		220	..	..	778	122	..	61	..	518.8	160.7	336.9	36.0	69.8	204.2	13.0	8.4
IV.	No. 4,	117	..	..	407	64	..	32	..	263.6	85.4	171.7	19.0	36.5	102.6	6.4	8.1
		220	..	..	772	122	..	62	..	509.8	162.8	325.8	36.2	68.8	194.9	12.2	8.0
V.	No. 4,	115	..	..	404	64	..	32	..	267.3	85.5	171.1	18.8	36.5	102.3	6.0	8.1
		208	..	..	767	122	..	62	..	496.9	162.3	320.5	35.4	67.6	192.0	11.2	8.0

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow / Number of ration	Pounds eaten of: Hay	Oat hay	Barn grass hay	Silage	Wheat bran	½ cottonseed meal ½ linseed meal	Hominy feed	½ cottonseed meal ½ corn meal	Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period: Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	Nutritive ratio, 1:
	REBECCA																
I.	No. 4,	60	..	59	400	63	..	19	14	259.4	84.2	166.2	19.9	33.0	98.0	5.3	7.2
		115	49	57	782	122	..	62	..	506.7	161.4	315.2	36.7	64.7	187.1	11.4	7.6
II.	No. 4,	60	48	..	406	63	..	32	..	259.6	83.8	163.5	18.2	32.4	99.7	5.9	8.0
		161	55	..	772	121	..	61	..	500.6	158.3	320.1	35.2	64.2	195.8	11.5	8.1
III.	No. 4,	116	..	..	390	62	..	31	..	263.2	80.7	169.3	17.9	35.6	103.4	6.4	8.6
		215	..	..	749	122	..	62	..	509.2	161.6	330.9	35.4	68.0	201.0	12.8	8.4
IV.	No. 4,	114	..	..	399	64	..	32	..	259.5	85.4	169.2	18.8	35.7	101.2	6.4	8.1
		222	..	..	756	122	..	62	..	508.4	162.8	324.8	36.1	68.5	194.3	12.2	8.0
V.	No. 4,	113	..	..	394	64	..	32	..	263.6	85.5	168.7	18.6	35.8	101.0	6.0	8.1
		218	..	..	757	122	..	62	..	503.7	162.3	324.4	35.8	68.7	194.1	11.3	8.1
	CHI																
I.	No. 1,	60	..	58	400	63	19	..	14	259.1	84.6	163.7	23.9	33.5	90.3	6.4	5.8
		115	45	59	781	122	62	..	..	506.1	162.8	307.6	49.7	66.2	162.3	12.9	5.2
II.	No. 5,	60	52	..	408	34	32	30	..	264.4	84.9	169.5	24.8	33.9	95.4	7.5	5.9
		158	63	..	781	62	61	61	..	510.0	161.4	332.1	47.8	66.6	188.1	14.5	6.0
III.	No. 1,	116	..	..	408	62	32	2	..	271.0	84.5	170.7	25.2	37.3	94.0	7.4	5.9
		224	..	..	782	122	62	..	..	525.7	163.2	334.0	51.5	71.7	181.8	14.8	5.6
IV.	No. 5,	116	..	..	408	34	32	30	..	263.2	85.6	175.5	25.7	36.9	97.0	8.0	5.9
		227	..	..	779	62	61	61	..	519.0	164.5	339.3	49.4	71.3	187.9	15.6	6.0
V.	No. 1,	118	..	..	406	62	32	2	..	271.4	86.6	169.6	27.0	37.5	90.3	6.9	5.3
		216	..	..	778	122	62	..	..	507.4	163.6	319.9	51.2	70.3	170.8	13.2	5.3
	LUCERNE																
I.	No. 5,	40	38	33	400	44	19	19	14	254.0	84.4	164.6	23.5	32.8	92.1	6.8	6.0
		115	44	57	779	62	61	61	..	502.0	161.6	321.0	48.5	67.1	175.1	14.0	5.6
II.	No. 1,	60	51	..	406	61	31	2	..	261.1	83.4	161.5	25.0	34.6	87.4	6.8	5.5
		157	55	..	779	121	62	..	..	507.8	160.7	314.2	48.2	68.0	170.4	12.8	5.5
III.	No. 5,	115	..	..	404	34	31	29	..	268.5	82.4	176.0	24.2	38.6	98.2	7.8	6.4
		208	..	..	775	61	60	60	..	503.7	160.0	339.5	47.2	72.2	190.3	15.7	6.3
IV.	No. 1,	110	..	..	406	62	32	2	..	259.9	86.6	166.0	26.3	37.7	88.3	7.1	5.4
		211	..	..	771	122	62	..	..	506.2	163.6	316.6	50.4	71.9	167.9	13.6	5.4
V.	No. 5,	110	..	..	405	33	31	29	..	265.9	83.5	171.7	24.5	38.0	94.2	7.3	6.1
		217	..	..	764	62	61	61	..	510.7	164.3	335.6	48.0	73.5	184.7	14.4	6.1
	FATIMA																
I.	No. 1,	60	..	46	356	63	19	..	14	241.4	84.6	153.1	23.0	30.5	85.0	6.3	5.6
		115	44	49	687	122	62	..	..	477.6	162.8	291.1	48.2	61.3	154.1	12.6	5.1
II.	No. 5,	60	42	..	351	32	31	30	..	241.5	82.2	155.5	23.3	30.4	87.9	7.1	5.8
		159	54	..	663	62	61	61	..	477.6	161.4	313.1	46.1	61.4	177.6	14.1	5.9
III.	No. 1,	113	..	..	333	62	32	2	..	252.0	84.5	159.4	24.4	33.9	87.4	7.1	5.6
		207	..	..	658	121	62	..	..	483.1	162.3	307.4	49.3	65.2	167.2	14.2	5.4
IV.	No. 5,	110	..	..	349	34	32	30	..	246.6	85.6	165.1	24.8	33.7	91.5	7.8	5.8
		216	..	..	606	62	61	61	..	474.7	164.5	312.1	47.2	62.8	173.7	14.9	5.7
V.	No. 1,	112	..	..	316	62	32	2	..	247.9	86.6	155.6	25.7	33.0	83.5	6.7	5.1
		182	..	..	610	121	62	..	..	443.4	162.7	280.6	47.7	58.5	150.0	12.4	5.0

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow Number of ration	Pounds eaten of: Hay	Oat hay	Barn grass hay	Silage	Wheat bran	½ cottonseed meal† ½ linseed meal	Hominy feed‡	½ cottonseed meal ½ corn meal	Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period: Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	Nutritive ratio, 1:
	SARNIA																
I.	No. 5,	40	40	36	400	44	19	19	14	257.8	84.4	166.5	23.7	33.5	92.9	6.8	6.0
		115	39	54	781	61	61	61	..	494.9	160.7	317.5	47.8	66.1	173.5	13.8	5.7
II.	No. 5,	60	43	..	407	32	32	31	..	255.3	84.0	165.9	24.2	33.5	93.1	7.3	5.9
		147	46	..	780	62	61	61	..	492.6	161.4	320.4	46.5	64.9	180.6	14.0	6.0
III.	No. 5,	100	..	..	397	32	31	31	..	254.1	82.3	168.0	23.5	35.8	94.3	7.6	6.3
		181	..	..	763	61	60	60	..	478.3	160.0	323.6	45.8	67.2	181.9	15.4	6.2
IV.	No. 5,	96	..	..	404	32	31	31	..	244.7	83.8	164.5	24.1	35.2	90.8	7.7	6.0
		192	..	..	770	62	61	61	..	490.0	164.5	321.6	47.1	68.7	177.5	14.9	5.9
V.	No. 5,	108	..	..	400	32	32	31	..	265.8	86.2	172.5	24.8	37.5	95.1	7.5	6.0
		215	..	..	767	62	61	61	..	509.5	164.3	334.8	48.0	73.2	184.4	14.4	6.0
	URSULA																
I.	No. 5,	60	..	52	400	55	24	24	18	275.8	105.6	181.3	26.9	33.3	103.6	8.0	5.8
		115	44	53	781	74	73	73	..	539.4	201.9	350.6	55.8	68.2	193.6	16.4	5.4
II.	No. 5,	60	46	..	407	40	40	39	..	279.0	105.2	183.2	28.3	34.8	103.6	8.6	5.6
		153	55	..	779	74	73	73	..	545.4	201.7	357.9	54.6	68.6	202.9	16.6	5.7
III.	No. 5,	111	..	..	406	40	40	40	..	288.2	105.1	192.1	28.4	38.8	108.5	9.0	5.9
		206	..	..	780	74	73	73	..	546.3	203.3	372.4	55.3	73.9	210.2	18.5	5.9
IV.	No. 5,	104	..	..	407	40	40	40	..	275.2	106.9	186.8	28.8	37.6	103.9	9.2	5.6
		213	..	..	778	74	73	73	..	551.4	205.6	365.0	55.8	74.2	202.6	17.8	5.7
V.	No. 5,	107	..	..	406	40	40	40	..	287.7	107.8	189.1	28.8	38.4	105.0	8.8	5.7
		209	..	..	777	74	73	73	..	547.3	205.4	364.2	55.5	74.3	202.2	17.0	5.7
	CONSTANCE																
I.	No. 1,	60	..	34	367	63	16	9	7	233.9	83.7	149.8	22.2	29.3	84.2	6.2	5.7
		115	11	25	553	117	30	29	..	396.0	155.8	246.5	42.6	48.8	132.6	11.3	4.9
II.	No. 6,	60	25	..	293	51	25	1	..	201.2	68.3	124.3	20.4	25.8	66.5	5.7	5.2
		154	44	..	511	121	61	..	..	431.2	160.3	269.1	46.6	54.2	143.0	13.0	4.9
III.	No. 1,	112	..	..	260	62	18	16	..	235.1	84.5	148.8	23.6	30.8	81.5	6.7	5.4
		185	..	..	458	119	30	30	..	417.1	158.8	266.1	45.7	52.7	144.5	12.8	4.9
IV.	No. 6,	117	..	..	222	62	32	2	..	229.6	87.3	145.0	25.5	29.9	75.9	7.4	4.8
		216	..	..	390	122	62	..	..	429.3	162.5	269.2	48.4	54.6	140.9	13.9	4.7
V.	No. 1,	112	..	..	217	62	18	16	..	228.0	86.7	142.6	24.9	29.1	76.2	6.5	4.8
		180	..	..	379	121	31	30	..	394.7	161.8	249.9	45.2	47.2	133.8	11.8	4.6
	ELSA																
I.	No. 6,	60	..	55	395	63	26	..	7	255.7	84.5	161.4	24.3	33.0	88.0	6.7	5.6
		115	49	55	782	122	62	..	..	505.9	162.3	306.3	51.5	66.6	157.7	13.8	5.0
II.	No. 1,	60	53	..	408	64	17	15	..	265.5	85.2	162.9	25.5	34.1	88.4	6.9	5.4
		160	61	..	778	122	31	31	..	509.4	161.6	317.5	48.8	66.8	173.7	13.2	5.5
III.	No. 6,	118	..	..	407	64	31	1	..	272.7	84.8	170.8	26.2	37.8	91.0	7.8	5.6
		217	..	..	776	122	62	..	..	518.2	163.0	328.4	52.0	70.6	175.5	15.8	5.4
IV.	No. 1,	118	..	..	403	64	17	15	..	265.1	86.8	168.4	27.1	37.0	89.7	7.3	5.3
		223	..	..	776	122	31	31	..	514.1	163.6	321.7	51.6	70.6	171.7	14.0	5.3
V.	No. 6,	120	..	..	405	64	31	1	..	273.6	87.2	170.1	27.4	37.8	89.1	7.6	5.3
		213	..	..	777	122	62	..	..	505.3	164.3	317.1	51.9	70.1	165.9	14.3	5.2

†Constance and Elsa, cottonseed meal only.
‡Constance and Elsa, linseed meal.

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow Number of ration	Pounds eaten of: Hay	Oat hay	Barn grass hay	Silage	Wheat bran	Cootonseed meal	Linseed meal	½ cottonseed meal ½ corn meal	Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period: Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	Nutritive ratio, 1:
GAMMA																	
I.	No. 1,	60	..	53	394	63	17	9	7	254.2	84.6	161.1	23.6	32.7	89.2	6.4	5.8
		115	43	54	767	122	31	31	..	497.4	162.8	302.9	49.1	64.8	160.2	12.8	5.2
II.	No. 6,	60	50	..	408	64	31	1	..	263.3	85.2	161.0	26.2	33.9	85.6	7.3	5.2
		157	60	..	779	122	62	..	..	506.9	162.1	314.3	50.4	66.7	168.0	14.1	5.3
III.	No. 1,	117	..	..	407	64	17	15	..	271.5	84.5	171.0	25.4	37.5	93.4	7.4	5.8
		225	..	..	781	122	31	31	..	526.3	163.2	334.4	51.5	71.8	181.9	14.8	5.6
IV.	No. 6,	115	..	..	399	64	31	1	..	262.2	87.3	166.0	27.1	36.5	86.9	7.9	5.2
		220	..	..	776	122	62	..	..	510.3	162.5	319.1	52.4	70.3	167.0	15.1	5.2
V.	No. 1,	117	..	..	407	64	17	15	..	270.9	86.7	169.2	26.9	37.5	90.1	6.9	5.3
		219	..	..	775	122	31	31	..	509.4	163.6	321.2	51.2	70.7	171.4	13.3	5.3
LAVENDER																	
I.	No. 1,	40	39	34	399	63	17	9	7	255.5	84.6	160.8	23.8	33.1	88.5	6.4	5.7
		115	45	53	782	122	31	31	..	501.5	162.8	306.0	49.4	67.2	160.6	12.8	5.2
II.	No. 1,	60	44	..	408	64	16	16	..	257.5	85.2	159.6	25.0	33.9	86.4	6.7	5.4
		149	49	..	779	122	31	31	..	496.8	161.6	308.1	47.8	65.9	167.5	12.7	5.5
III.	No. 1,	113	..	..	401	63	16	16	..	267.3	83.6	168.2	24.9	38.3	90.9	7.1	5.8
		200	..	..	779	122	31	31	..	501.0	163.2	322.7	49.7	71.2	174.8	14.3	5.6
IV.	No. 1,	105	..	..	408	64	16	16	..	256.1	86.7	163.2	26.1	36.9	86.6	7.1	5.4
		210	..	..	775	122	31	31	..	506.1	163.6	316.6	50.4	71.9	167.9	13.6	5.4
V.	No. 1,	108	..	..	406	64	16	16	..	267.8	86.6	165.6	26.2	37.8	87.8	6.7	5.4
		216	..	..	775	122	31	31	..	511.3	163.6	321.3	50.4	73.7	170.3	13.0	5.4
VIVIAN																	
I.	No. 1,	60	..	56	400	63	17	9	7	257.6	84.6	162.9	23.8	33.2	90.0	6.4	5.8
		115	45	53	782	122	31	31	..	501.5	162.8	305.4	49.4	65.5	161.5	12.9	5.2
II.	No. 1,	60	48	..	406	64	16	16	..	261.0	85.2	160.6	25.1	33.4	87.5	6.7	5.4
		161	55	..	780	122	31	31	..	505.6	161.6	315.8	48.6	66.3	172.8	13.1	5.5
III.	No. 1,	114	..	..	405	64	16	16	..	268.6	84.5	169.3	25.1	37.0	92.7	7.3	5.8
		204	..	..	780	122	31	31	..	508.0	163.2	323.3	50.5	68.6	176.2	14.6	5.5
IV.	No. 1,	113	..	..	407	64	16	16	..	261.5	86.7	166.4	26.8	36.5	88.8	7.3	5.3
		213	..	..	770	122	31	31	..	504.1	163.6	315.8	51.1	68.8	168.5	13.9	5.3
V.	No. 1,	111	..	..	400	64	16	16	..	264.1	86.6	165.3	26.5	36.3	88.2	6.8	5.3
		200	..	..	771	122	31	31	..	492.0	163.6	310.7	50.3	67.6	165.9	12.9	5.2
LAURA																	
I.	No. 6,	60	..	57	400	63	26	..	7	258.2	84.5	162.8	24.5	33.5	88.6	6.7	5.6
		115	37	47	746	120	60	..	..	478.5	158.8	291.3	49.4	62.5	150.6	13.3	4.9
II.	No. 6,	60	37	..	405	64	32	..	..	251.7	85.2	155.3	25.6	32.2	82.9	7.1	5.1
		153	50	..	778	122	62	..	..	494.9	162.1	308.1	49.8	64.8	165.1	13.9	5.3
III.	No. 6,	111	..	..	403	64	32	..	..	266.0	84.8	163.8	25.9	36.7	89.3	7.7	5.5
		218	..	..	778	122	62	..	..	519.4	163.0	329.2	52.1	70.8	175.9	15.8	5.4
IV.	No. 6,	118	..	..	404	64	32	..	..	265.9	87.4	168.0	27.6	37.2	88.0	7.9	5.2
		221	..	..	772	122	62	..	..	510.4	162.5	319.1	52.4	70.3	167.0	15.1	5.2
V.	No. 6,	117	..	..	395	64	32	..	..	269.1	87.3	167.2	27.3	37.1	87.5	7.5	5.2
		220	..	..	767	122	62	..	..	509.4	164.3	319.5	52.2	70.7	167.2	14.3	5.2

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow / Number of ration	Pounds eaten of: Hay	Oat hay	Barn grass hay	Silage	Wheat bran	Cootonseed meal	Linseed meal	½ cottonseed meal ½ corn meal	Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period: Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	Nutritive ratio, 1:
	CASSANDRA																
I.	No. 1,	60	..	55	367	63	17	9	7	250.4	84.6	158.3	23.4	31.9	87.6	6.3	5.7
		115	43	57	690	122	31	31	..	483.8	162.8	294.1	48.5	62.3	155.3	12.6	5.1
II.	No. 1,	60	49	..	358	63	16	15	..	249.9	83.5	153.5	24.4	31.8	83.3	6.5	5.3
		159	65	..	689	121	31	31	..	491.9	160.7	306.2	47.9	64.1	167.0	12.9	5.4
III.	No. 1,	117	..	..	339	64	16	16	..	261.0	84.5	164.3	24.8	35.7	89.9	7.1	5.7
		213	..	..	673	122	31	31	..	492.4	163.2	313.2	49.9	65.7	170.3	14.3	5.4
IV.	No. 1,	110	..	..	358	63	16	16	..	248.6	85.8	158.2	26.0	34.0	84.5	7.1	5.2
		218	..	..	679	121	31	31	..	489.2	162.7	306.5	50.3	66.0	163.6	13.6	5.2
V.	No. 1,	115	..	..	358	64	16	16	..	259.1	86.6	162.1	26.3	35.2	86.5	6.8	5.2
		213	..	..	683	122	31	31	..	485.8	163.6	306.4	50.1	66.0	163.6	13.0	5.2
	ALTA																
I.	No. 1,	40	39	35	400	63	17	9	7	256.5	84.6	161.3	24.0	33.4	88.6	6.4	5.7
		115	45	53	780	121	30	30	..	498.4	160.2	304.0	48.9	67.1	159.5	12.5	5.2
II.	No. 7,	60	46	..	401	62	1	30	..	254.7	82.2	158.2	24.4	33.5	86.4	6.1	5.5
		153	53	..	773	121	..	61	..	500.1	159.4	310.9	47.5	66.3	170.6	11.7	5.5
III.	No. 1,	114	..	..	406	63	15	16	..	268.4	82.7	168.9	24.8	38.6	91.3	7.1	5.9
		216	..	..	775	121	30	30	..	510.9	160.5	328.9	49.9	73.6	177.8	14.4	5.7
IV.	No. 7,	108	..	..	403	63	1	31	..	256.7	85.7	164.3	25.0	37.2	88.2	6.4	5.6
		205	..	..	764	119	..	60	..	495.1	159.3	310.8	47.0	70.6	167.1	12.0	5.6
V.	No. 1,	102	..	..	400	58	14	15	..	252.6	78.5	156.2	24.1	36.1	82.8	6.1	5.5
		197	..	..	758	120	30	30	..	487.3	160.0	306.8	48.8	69.7	162.6	12.5	5.3
	ADELAIDE																
I.	No. 7,	40	32	35	398	61	7	19	7	248.5	82.8	157.3	23.1	32.2	87.2	6.0	5.8
		115	20	20	625	87	..	44	..	374.1	115.4	232.4	35.8	51.7	124.5	8.6	5.5
II.	No. 1,	60	38	..	377	54	13	15	..	233.6	72.8	144.8	22.0	31.4	78.3	5.8	5.6
		146	51	..	668	115	29	29	..	462.3	151.9	286.0	44.7	61.2	154.9	12.0	5.4
III.	No. 7,	101	..	..	279	44	2	21	..	205.3	58.5	129.2	18.3	30.3	70.1	4.9	6.1
		209	..	..	682	115	..	58	..	476.7	152.4	308.7	45.2	68.6	168.8	12.1	5.9
IV.	No. 1,	100	..	..	278	50	12	13	..	207.5	67.7	132.0	20.8	30.3	70.0	5.8	5.5
		201	..	..	675	122	31	31	..	478.0	163.6	299.4	49.0	66.5	159.0	13.2	5.2
V.	No. 7,	105	..	..	352	63	1	32	..	253.2	86.0	157.7	24.3	35.1	84.8	5.9	5.4
		205	..	..	670	122	..	62	..	480.4	163.4	303.5	46.7	67.8	163.3	11.2	5.5
	STAR BRIGHT																
I.	No. 1,	60	..	51	400	63	17	9	7	253.9	84.6	161.0	23.6	32.6	89.3	6.4	5.8
		115	45	50	778	122	31	31	..	498.2	162.8	303.8	49.3	65.0	160.9	12.8	5.2
II.	No. 7,	60	49	..	407	64	1	31	..	261.7	84.9	161.6	25.1	33.4	88.8	6.2	5.4
		162	61	..	778	122	..	62	..	510.6	161.2	319.6	48.7	66.6	176.6	12.1	5.6
III.	No. 1,	119	..	..	407	63	14	16	..	270.6	81.9	170.3	24.8	37.7	93.2	7.1	5.9
		224	..	..	776	122	31	31	..	524.4	163.2	333.2	51.5	71.4	181.4	14.8	5.6
IV.	No. 7,	116	..	..	407	64	1	31	..	263.9	86.6	168.7	25.8	36.9	91.2	6.6	5.5
		223	..	..	777	122	..	62	..	514.4	163.7	323.2	49.4	70.8	174.7	12.6	5.5
V.	No. 1,	118	..	..	405	64	15	17	..	271.2	86.6	169.5	26.9	37.5	90.5	6.8	5.3
		201	..	..	672	105	26	26	..	449.2	139.6	282.7	44.7	63.0	150.8	11.4	5.4

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow / Number of ration	Pounds eaten of: Hay	Oat hay	Barn grass hay	Silage	Wheat bran	Cottonseed meal	Linseed meal	½ cottonseed meal ½ corn meal	Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period: Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	Nutritive ratio, 1:
YEMASSEE																	
I.	No. 1,	60	..	55	400	63	17	9	7	256.8	84.6	162.5	23.8	33.1	89.9	6.4	5.8
		115	37	57	782	122	31	31	..	498.0	162.8	303.6	49.2	64.9	160.6	12.8	5.2
II.	No. 1,	60	59	..	403	64	16	16	..	269.4	85.2	164.7	25.6	34.8	89.2	6.8	5.4
		156	52	..	776	122	31	31	..	498.1	161.6	311.5	48.2	65.0	171.0	13.1	5.5
III.	No. 1,	106	..	..	408	64	16	16	..	262.6	84.5	165.7	24.8	35.9	90.9	7.2	5.8
		206	..	..	780	122	31	31	..	509.7	163.2	324.3	50.6	68.9	176.7	14.6	5.5
IV.	No. 1,	116	..	..	400	64	16	16	..	262.6	86.7	167.1	26.9	36.6	89.2	7.3	5.3
		216	..	..	748	122	31	31	..	502.3	163.6	314.7	51.0	68.4	168.0	13.8	5.2
V.	No. 1,	115	..	..	387	64	16	16	..	265.0	86.6	165.8	26.6	36.4	88.4	6.9	5.3
		203	..	..	767	122	31	31	..	493.6	163.6	311.8	50.5	68.0	166.4	12.9	5.2
MU																	
I.	No. 1,	60	..	60	400	63	17	9	7	260.5	84.6	164.4	24.0	33.7	90.6	6.4	5.8
		115	49	60	782	122	31	31	..	510.5	162.8	309.6	49.9	66.8	163.2	13.0	5.2
II.	No. 1,	60	59	..	408	64	16	16	..	270.5	85.2	165.4	25.7	35.0	89.6	6.8	5.4
		163	63	..	782	122	31	31	..	514.4	161.6	320.3	49.1	67.8	175.2	13.3	5.6
III.	No. 1,	116	..	..	408	64	16	16	..	271.0	84.5	170.7	25.2	37.4	93.5	7.3	5.8
		223	..	..	778	122	31	31	..	523.9	163.2	332.9	51.4	71.4	181.2	14.8	5.6
IV.	No. 1,	118	..	..	407	64	16	16	..	265.8	86.7	169.0	27.1	37.2	90.2	7.3	5.3
		228	..	..	781	122	31	31	..	519.4	163.6	325.0	52.0	71.6	173.4	14.1	5.3
V.	No. 1,	119	..	..	408	64	16	16	..	272.7	86.6	170.5	27.0	37.8	90.9	7.0	5.4
		228	..	..	781	122	31	31	..	518.5	163.6	326.5	51.8	72.3	174.1	13.4	5.3
MERMAID																	
I.	No. 1,	40	38	38	400	62	17	9	7	257.0	83.7	161.4	23.9	33.5	88.4	6.4	5.7
		115	53	58	782	122	31	31	..	512.2	162.8	311.1	50.0	68.8	162.8	12.9	5.2
II.	No. 1,	60	56	..	408	64	16	16	..	267.4	85.2	164.6	25.5	35.5	88.6	6.8	5.5
		152	61	..	780	122	31	31	..	509.8	161.6	314.7	48.5	67.9	170.3	13.0	5.5
III.	No. 1,	115	..	..	407	64	16	16	..	271.2	84.5	170.7	25.2	39.0	92.2	7.2	5.9
		221	..	..	781	121	31	31	..	518.2	162.3	333.5	50.5	74.7	180.2	14.6	5.7
IV.	No. 1,	113	..	..	408	64	16	16	..	263.0	86.7	167.5	26.5	38.3	88.7	7.2	5.4
		216	..	..	778	122	31	31	..	512.0	163.6	320.1	50.6	73.0	169.7	13.7	5.4
V.	No. 1,	112	..	..	405	64	16	16	..	270.8	86.6	167.3	26.4	38.4	88.7	6.7	5.4
		219	..	..	780	122	31	31	..	515.0	163.6	323.5	50.7	74.4	171.5	13.0	5.4
ROSEL																	
I.	No. 1,	40	37	35	400	63	17	9	7	254.8	84.6	160.5	23.8	33.1	88.3	6.4	5.7
		115	47	46	780	122	31	31	..	497.0	162.8	303.8	49.2	66.5	159.9	12.7	5.2
II.	No. 1,	60	47	..	407	64	16	16	..	259.8	85.2	160.7	25.1	34.3	86.9	6.7	5.4
		145	50	..	780	121	31	31	..	494.5	161.6	306.6	47.7	65.3	166.5	12.8	5.5
III.	No. 1,	119	..	..	407	64	16	16	..	274.6	84.5	172.8	25.3	39.7	93.2	7.2	5.9
		190	..	..	778	122	31	31	..	492.4	163.2	317.3	49.2	69.4	172.0	14.2	5.6
IV.	No. 1,	104	..	..	407	64	16	16	..	255.0	86.7	162.6	26.1	36.8	86.3	7.1	5.3
		194	..	..	780	122	31	31	..	492.9	163.6	308.7	49.6	69.4	163.9	13.4	5.3
V.	No. 1,	103	..	..	408	64	16	16	..	263.2	86.6	163.0	25.9	37.0	86.4	6.6	5.3
		204	..	..	775	122	31	31	..	500.6	163.6	315.0	49.9	71.7	167.1	12.9	5.4

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow / Number of ration	Pounds eaten of: Hay	Oat hay	Barn grass hay	Silage	Wheat bran	Cottonseed meal	Linseed meal	½ cottonseed meal ½ corn meal	Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period: Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	Nutritive ratio, 1:
	JANICE																
I.	No 7,	60	..	52	368	63	7	19	7	248.3	84.6	158.4	23.3	31.6	88.3	6.0	5.7
		115	42	50	690	122	..	62	..	476.7	162.1	292.2	48.0	60.8	156.5	11.5	5.1
II.	No. 7,	60	42	..	356	63	..	31	..	243.4	83.1	150.8	24.0	30.5	83.0	6.0	5.3
		161	58	..	687	122	..	62	..	487.6	161.2	305.7	47.6	62.8	168.9	11.8	5.4
III.	No. 7.	116	..	..	357	64	..	32	..	259.0	83.7	164.3	24.6	35.1	80.8	6.5	5.3
		213	..	..	688	122	..	62	..	494.6	162.1	316.5	47.8	66.5	174.4	13.0	5.7
IV.	No. 7,	117	..	..	406	64	..	32	..	264.6	86.6	169.0	25.8	37.1	91.3	6.5	5.5
		217	..	..	778	122	..	62	..	509.3	163.7	320.2	49.1	69.9	173.1	12.5	5 5
V.	No. 7,	113	..	..	402	64	..	32	..	265.7	86.0	167.3	25.5	36.8	90.3	6.1	5.5
		193	..	..	770	122	..	62	..	485.5	163.4	308.3	47.8	66.7	166.8	11.4	5.4
	JUDITH																
I.	No. 6,	40	36	26	398	63	26	..	7	246.8	84.5	156.0	23.8	31.8	85.1	6.6	5.5
		115	36	45	658	112	56	..	..	447.2	148.2	272.5	46.2	60.2	139.5	12.4	4.9
II.	No. 7,	60	38	..	402	64	2	30	..	251.0	84.9	156.9	24.6	32.6	85.8	6.1	5.4
		142	45	..	776	121	..	62	..	435.5	160.3	303.1	46.9	63.5	166.7	11.5	5.5
III.	No. 6,	102	..	..	393	62	30	2	..	255.7	83.0	160.4	25.0	36.2	85.0	7.4	5.6
		184	..	..	754	119	59	..	..	476.7	157.7	306.3	48.6	67.4	162.7	14.8	5.4
IV.	No. 7,	106	..	..	406	64	2	30	..	256.5	86.6	164.1	25.1	37.0	88.0	6.4	5.6
		207	..	..	744	122	..	62	..	497.2	163.7	312.5	47.7	70.4	168.0	12.1	5.6
V.	No. 6,	101	..	..	346	62	32	2	..	249.4	87.2	153.6	25.6	34.2	80.0	7.0	5.1
		205	..	..	656	122	62	..	..	478.5	164.3	299.4	49.7	67.2	155.6	13.7	5.1
	YUBA																
I.	No. 7,																
		115	53	55	779	120	..	60	..	504.7	158.5	307.7	49.0	65.9	164.1	11.6	5.2
II.	No. 6,	60	57	..	405	64	30	2	..	268.2	85.2	164.0	26.5	34.8	87.0	7.2	5.2
		164	63	..	782	122	62	..	..	515.7	162.1	319.4	50.9	68.3	170.6	14.2	5.3
III.	No. 7,	118	..	..	408	64	2	30	..	272.0	83.8	172.1	25.3	37.4	95.0	6.8	5.8
		227	..	..	781	122	..	62	..	526.9	162.1	336.7	49.4	72.3	185.4	13.5	5.8
IV.	No. 6,	119	..	..	408	64	30	2	..	267.4	87.3	169.2	27.4	37.4	88.7	7.9	5.3
		227	..	..	779	122	62	..	..	517.0	162.5	323.1	52.7	71.5	169.1	15.2	5.2
V.	No. 7,	119	..	..	407	64	2	30	..	272.0	86.1	171.0	25.9	37.8	92.2	6.3	5.6
		225	..	..	781	122	..	62	..	515.7	163.4	326.3	49.4	72.0	176.2	11.9	5.6
	ZILLAH																
I.	No. 7,	60	..	50	368	62	7	19	7	246.0	83.7	156.3	23.0	31.1	87.4	5.9	5.7
		115	43	52	689	121	..	61	..	477.1	160.3	292.0	47.7	61.1	156.1	11.4	5.1
II.	No. 6,	60	47	..	360	64	30	2	..	250.5	85.2	153.4	25.5	31.8	81.5	7.0	5.1
		160	52	..	682	120	61	..	..	478.9	159.5	297.7	48.6	62.6	159.0	13.6	5.2
III.	No. 7,	115	..	..	353	64	2	30	..	257.4	83.8	163.1	24.7	34.8	90.0	6.6	5.7
		216	..	..	681	121	..	61	..	493.7	160.3	316.0	47.7	66.6	174.0	12.8	5.6
IV.	No. 6,	115	..	..	357	64	30	2	..	254.1	87.3	160.8	26.7	34.8	84.3	7.7	5.1
		220	..	..	686	121	60	..	..	492.2	162.5	306.3	51.0	66.7	160.3	14.8	5.1
V.	No. 7,	114	..	..	347	61	2	29	..	252.0	82.6	158.3	24.4	34.5	85.4	5.9	5.5
		206	..	..	632	120	..	60	..	465.8	159.8	295.2	46.4	63.1	159.8	11.2	5.3

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow / Number of ration	Pounds eaten of: Hay	Oat hay	Barn grass hay	Silage	Wheat bran	Cottonseed meal	Linseed meal	½ cottonseed meal ½ corn meal	Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period: Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	Nutritive ratio, 1:
	POMONA																
I.	No. 6,	40	35	7	394	63	26	..	7	231.2	84.5	147.1	22.7	29.0	81.5	6.5	5.5
		115	25	27	762	120	60	..	..	455.7	158.8	281.5	48.2	60.9	145.9	13.1	4.9
II.	No. 6,	60	26	..	356	64	32	..	..	231.7	85.2	144.6	24.6	29.9	76.6	6.9	5.0
		138	30	..	675	121	61	..	..	447.6	160.3	278.3	46.9	58.1	148.0	12.9	5.2
III.	No. 6,	86	..	..	356	63	31	..	..	234.0	83.0	147.3	24.0	32.2	77.9	7.0	5.3
		185	..	..	679	121	60	..	..	463.8	160.4	298.2	48.5	64.8	158.2	14.7	5.3
IV.	No. 6,	104	..	..	359	64	32	..	..	246.3	87.4	156.0	26.1	35.0	81.1	7.6	5.1
		197	..	..	684	122	62	..	..	475.1	162.5	297.3	49.8	66.4	154.6	14.4	5.1
V.	No. 6,	102	..	..	348	64	32	..	..	250.8	87.3	154.4	25.8	34.5	80.2	7.1	5.1
		200	..	..	659	121	61	..	..	472.8	162.5	296.0	49.2	66.6	153.8	13.5	5.1
	MYRTLE																
I.	No. 7,	60	..	58	368	63	7	19	7	252.8	84.6	159.9	23.4	32.1	88.8	6.0	5.7
		115	49	53	690	122	..	62	..	484.9	162.1	296.2	48.4	62.1	158.2	11.5	5.1
II.	No. 7,	60	51	..	360	64	..	32	..	253.5	84.9	156.2	24.7	31.9	85.7	6.1	5.3
		161	56	..	689	122	..	62	..	486.3	161.2	305.1	47.5	62.7	168.7	10.8	5.3
III.	No. 7,	114	..	..	356	63	..	32	..	256.2	82.8	162.6	24.4	34.6	89.8	6.5	5.7
		222	..	..	687	122	..	62	..	502.1	162.1	321.1	48.3	67.8	176.8	13.1	5.7
IV.	No. 7,	118	..	..	360	64	..	32	..	256.5	86.6	163.8	25.4	35.4	88.6	6.4	5.5
		223	..	..	685	122	..	62	..	495.9	163.7	311.7	48.5	67.2	168.7	12.4	5.4
V.	No. 7,	118	..	..	352	64	..	32	..	259.9	86.0	163.6	25.3	35.5	88.4	6.0	5.4
		215	..	..	682	122	..	62	..	487.2	163.4	308.6	48.0	66.6	167.0	11.6	5.4
	MINTA BELLA																
I.	No. 1,	60	24	23	408	63	32	..	..	257.5	.....	157.0	25.4	33.6	83.4	6.6	5.2
		115	83	..	780	122	61	..	..	492.4	.....	303.9	47.7	63.0	165.9	12.8	5.4
II.	No. 1,	80	29	..	408	64	32	..	..	261.0	.....	163.1	25.2	33.8	89.4	6.8	5.5
		210	..	..	774	122	61	..	..	511.3	.....	325.2	50.6	69.3	177.0	14.6	5.5
III.	No. 1,	107	..	..	407	64	32	..	..	257.7	.....	164.2	26.3	37.3	87.1	7.1	5.3
		212	..	..	769	122	62	..	..	503.2	.....	315.1	51.0	68.5	168.1	13.9	5.3
IV.	No. 1,	102	..	..	276	52	26	..	..	213.7	.....	133.2	21.6	29.0	71.2	5.8	5.2
		212	..	..	630	122	62	..	..	475.6	.....	298.0	49.6	63.2	159.3	13.5	5.1
	VALENTINE																
I.		60	27	24	360	64	32	..	..	251.7	.....	153.1	25.2	32.4	81.0	6.5	5.1
		115	68	..	681	121	61	..	..	458.2	.....	284.0	45.9	57.4	155.1	12.3	5.2
II.		76	31	..	358	64	32	..	..	248.7	.....	155.2	24.6	32.0	84.9	6.6	5.4
		207	..	..	687	122	61	..	..	489.7	.....	311.5	49.5	65.4	169.5	14.3	5.4
III.		106	..	..	356	63	32	..	..	246.0	.....	156.7	25.5	35.0	83.1	7.0	5.3
		216	..	..	674	122	61	..	..	486.4	.....	304.8	50.1	65.4	162.8	13.6	5.2
IV.		115	..	..	339	62	31	..	..	242.4	.....	152.6	25.3	32.5	81.6	6.9	5.1
		212	..	..	662	122	62	..	..	481.1	.....	301.3	49.8	64.3	161.1	13.6	5.1

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow / Number of ration	Pounds eaten of: Hay	Oat hay	Barn grass hay	Silage	Wheat bran	½ cottonseed meal ½ linseed meal		Total dry matter in entire ration	Total dry matter in experimental feed	Pounds of digestible nutrients eaten during period: Dry matter	Protein	Crude fiber	Nitrogen-free extract	Ether extract	Nutritive ratio, 1:
	GRACE															
I.		60	22	16	342	48	24	.. ..	213.7	.....	132.0	20.3	30.2	69.2	5.2	5.5
		115	60	..	687	92	46	.. ..	412.7	.....	256.1	38.1	56.7	138.6	10.3	5.7
II.		74	32	..	352	48	24	.. ..	228.7	.....	140.1	20.5	31.9	75.4	5.5	5.8
		208	..	..	686	92	46	.. ..	446.4	.....	286.4	40.9	67.1	154.6	11.8	6.1
III.		113	..	..	360	48	24	.. ..	231.9	.....	147.2	21.7	35.5	77.7	5.9	5.8
		210	..	..	688	92	46	.. ..	448.0	.....	278.7	41.4	66.9	147.0	11.2	5.8
IV.		117	..	..	356	48	24	.. ..	239.6	.....	148.4	21.8	35.9	78.3	5.9	5.8
		220	..	..	688	92	46	.. ..	456.8	.....	283.7	41.6	68.7	149.9	11.4	5.9
	IRENE															
I.		60	22	34	408	64	32	.. ..	265.6	.....	161.0	25.9	34.8	85.0	6.6	5.2
		115	90	..	780	122	62	.. ..	499.1	.....	307.3	48.2	63.9	167.5	13.0	5.4
II.		80	36	..	407	64	32	.. ..	266.8	.....	165.8	25.5	35.1	90.6	6.9	5.5
		223	..	..	780	122	62	.. ..	524.3	.....	333.1	51.4	71.5	181.4	14.8	5.6
III.		105	..	..	407	64	32	.. ..	256.3	.....	163.2	26.2	37.0	86.5	7.1	5.3
		221	..	..	773	122	62	.. ..	511.8	.....	320.5	51.5	70.2	171.2	14.0	5.3
	HAIDEE															
I.		60	22	34	408	64	32	.. ..	265.6	.....	161.0	25.9	34.8	85.0	6.6	5.2
		115	106	..	781	122	62	.. ..	512.5	.....	314.1	49.0	66.0	170.4	13.2	5.4
II.		8[illegible]	36	..	408	64	32	.. ..	267.0	.....	166.0	25.5	35.1	90.7	6.9	5.5
		2[illegible]	..	..	779	122	62	.. ..	526.4	.....	334.1	51.5	71.7	181.8	14.8	5.6
III.		115	..	..	408	64	32	.. ..	263.4	.....	167.6	26.9	36.8	89.4	7.3	5.3
		227	..	..	781	122	62	.. ..	518.5	.....	324.5	51.9	71.4	173.2	14.1	5.3
	SHEILA															
I.		60	28	25	360	64	32	.. ..	253.3	.....	153.9	25.3	32.6	81.4	6.6	5.1
		115	68	..	685	121	60	.. ..	458.1	.....	283.9	45.8	57.5	155.1	12.4	5.3
II.		76	31	..	357	64	32	.. ..	248.5	.....	155.0	24.6	32.0	84.8	6.6	5.4
		205	..	..	679	121	61	.. ..	485.4	.....	308.8	49.4	64.8	167.9	14.2	5.4
III.		110	..	..	353	63	32	.. ..	247.6	.....	157.6	26.0	33.8	84.1	7.1	5.2
		209	..	..	644	122	62	.. ..	479.4	.....	300.0	49.1	66.5	159.1	13.3	5.2
	LIZZIE HEXHAM															
I.		60	24	29	408	64	32	.. ..	263.2	.....	159.9	25.8	34.4	84.7	6.7	5.2
		115	90	..	777	122	62	.. ..	498.4	.....	306.9	48.2	63.8	167.2	13.0	5.4
II.		80	30	..	407	64	32	.. ..	261.7	.....	163.3	25.2	34.3	89.5	6.8	5.5
		206	..	..	769	122	62	.. ..	507.5	.....	322.9	50.6	68.5	175.9	14.6	5.5
III.		110	..	..	408	64	32	.. ..	259.2	.....	165.0	26.7	36.0	88.0	7.2	5.3
		222	..	..	778	122	62	.. ..	513.6	.....	321.5	51.6	70.4	171.6	14.0	5.3

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

V. RECORD SHOWING PRODUCTION AND SAME PER UNIT FOR EACH INDIVIDUAL COW IN FEEDING TESTS

Period numbers	Name of cow / Experimental ration	Dry matter eaten*	Dry matter eaten†	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten — In entire ration: Milk	Total solids	Fat	In experimental feed: Milk	Total solids	Fat
		lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
	ELIZABETH													
I.	No. 1,	250.5	84.6	250.0	14.89	5.23	37.22	13.07	99.8	14.9	5.22	295.5	44.0	15.5
		485.1	162.8	441.4	15.25	5.47	67.32	24.16	91.0	13.9	4.98	271.2	41.4	14.8
II.	No. 2,	249.9	83.0	211.8	15.52	5.59	32.88	11.84	84.8	13.2	4.74	255.2	39.6	14.3
		485.9	157.5	354.7	16.00	6.00	56.76	21.27	73.0	11.7	4.38	225.2	36.0	13.5
III.	No. 1,	261.2	84.5	177.2	16.42	6.37	29.09	11.29	67.8	11.1	4.32	209.7	34.4	13.4
		503.7	163.2	327.8	16.12	6.20	52.86	20.32	65.1	10.5	4.03	200.9	32.4	12.5
IV.	No. 2,	251.9	85.4	161.7	15.69	6.00	25.87	9.71	64.2	10.3	3.85	189.4	30.3	11.4
		491.0	161.7	289.9	15.81	6.22	45.85	18.04	59.0	9.3	3.67	179.3	28.4	11.2
V.	No. 1,	259.9	86.6	152.4	16.18	6.34	24.66	9.67	58.6	9.5	3.72	176.0	28.5	11.2
		478.2	163.6	270.8	15.96	6.30	43.23	17.08	56.6	9.0	3.57	165.5	26.4	10.4
	INEZ													
II.	No. 1,	248.6	85.2	317.6	14.48	5.23	45.99	16.60	127.8	18.5	6.68	372.8	54.0	19.5
		513.1	161.6	620.9	14.26	5.06	88.52	31.42	121.0	17.3	6.12	384.2	54.8	19.4
III.	No. 2,	270.5	82.3	298.4	14.48	5.15	43.22	15.37	110.3	16.0	5.68	362.6	52.5	18.7
		524.2	159.7	524.1	14.61	5.23	76.59	27.42	100.0	14.6	5.23	328.2	48.0	17.2
IV.	No. 1,	264.4	86.6	248.5	14.67	5.44	36.47	13.53	94.0	13.8	5.12	287.0	42.1	15.6
		516.8	163.6	500.5	14.90	5.47	74.57	27.34	96.9	14.4	5.29	305.9	45.6	16.7
V.	No. 2,	272.0	86.1	233.7	14.95	5.42	34.93	12.66	85.9	12.8	4.65	271.5	40.6	14.7
		502.1	161.2	447.9	14.83	5.42	66.42	24.28	89.2	13.2	4.84	277.8	41.2	15.1
	HALLOWE'EN													
I.	No. 2,	248.0	83.5	119.6	15.09	5.47	18.05	6.54	48.2	7.3	2.64	143.1	21.6	7.3
		478.8	158.2	215.9	15.49	5.69	33.44	12.28	45.1	7.0	2.57	136.5	21.1	7.8
II.	No. 1,	243.1	85.2	110.2	15.49	5.80	17.07	6.39	45.3	7.0	2.63	129.3	20.0	7.5
		478.3	160.7	211.6	15.38	5.70	32.54	12.07	44.2	6.8	2.52	131.7	20.3	7.5
III.	No. 2,	251.7	78.8	101.2	15.82	6.05	16.01	6.12	40.2	6.4	2.43	128.4	20.3	7.8
		482.8	151.9	162.8	16.05	6.27	26.13	10.21	33.7	5.4	2.11	107.2	17.2	6.7
	EVA													
I.	No. 2,	254.3	83.5	277.3	14.14	4.75	39.21	13.17	109.1	15.4	5.18	332.1	47.0	15.8
		500.9	158.2	496.2	14.28	4.98	70.85	24.71	99.1	14.1	4.93	313.6	44.8	15.6
II.	No. 2,	261.4	82.8	236.7	14.43	5.10	34.16	12.07	90.5	13.1	4.62	285.9	41.3	14.6
		507.5	157.5	407.5	15.18	5.51	61.86	22.44	80.3	12.2	4.42	258.7	39.3	14.3
III.	No. 2,	267.8	82.1	198.0	15.65	5.85	30.99	11.58	73.9	11.6	4.32	241.2	37.7	14.1
		523.7	159.7	352.4	15.52	5.82	54.70	20.52	67.3	10.4	3.92	220.7	34.3	12.8
IV.	No. 2,	264.4	85.3	170.0	15.70	6.10	26.69	10.37	64.3	10.1	3.92	199.3	31.3	12.2
		515.6	161.7	332.4	15.92	6.09	52.91	20.33	64.5	10.3	3.92	205.6	32.7	12.5
V.	No. 2,	271.1	86.1	175.2	16.20	6.20	28.38	10.86	64.6	10.5	4.01	203.5	33.0	12.6
		495.2	161.2	323.7	15.81	6.13	51.19	19.83	65.4	10.3	4.00	200.8	31.8	12.3

*In total ration. †In experimental portion of ration.

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow / Experimental ration	Dry matter eaten*	Dry matter eaten†	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten					
									In entire ration			In experimental feed		
									Milk	Total solids	Fat	Milk	Total solids	Fat
		lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
FRESNO														
II.	No. 2,	257.8	82.8	330.1	13.45	4.25	44.41	14.02	128.1	17.2	5.44	398.7	53.6	16.9
		502.8	157.5	597.4	13.41	4.21	80.12	25.17	118.8	15.9	5.01	379.6	50.9	16.0
III.	No. 2,	269.8	82.1	289.9	13.32	4.23	38.60	12.25	107.5	14.3	4.54	353.1	47.0	14.9
		497.2	149.3	499.0	13.53	4.35	67.51	21.72	100.4	13.6	4.37	334.2	45.2	14.5
IV.	No. 2,	262.5	85.3	237.2	13.47	4.31	31.95	10.22	90.4	12.2	3.89	278.1	37.5	12.0
		512.1	161.7	476.6	13.47	4.32	64.20	20.58	93.1	12.5	4.02	294.7	39.7	12.7
V.	No. 2,	269.7	86.1	252.2	13.31	4.12	33.57	10.39	93.5	12.4	3.85	293.0	39.0	12.1
		480.0	161.2	450.8	13.17	4.18	59.37	18.84	93.9	12.4	3.93	279.6	36.8	11.7
ZIRCONIA														
I.	No. 1,	245.5	84.6	247.2	14.71	5.04	36.35	12.45	100.7	14.8	5.07	292.2	43.0	14.7
		476.4	162.8	487.4	14.32	4.92	69.78	24.00	102.3	14.6	5.04	299.4	42.9	14.7
II.	No. 3,	248.3	81.6	261.2	14.27	4.79	37.26	12.50	105.2	15.0	5.03	320.2	45.7	15.3
		493.9	159.2	460.6	14.46	4.75	66.61	21.88	93.2	13.5	4.43	289.4	41.9	13.7
III.	No. 1,	257.0	83.6	230.5	14.64	4.85	33.74	11.18	89.7	13.1	4.35	275.7	40.4	13.4
		492.8	163.2	402.2	14.59	4.94	58.69	19.88	81.6	11.9	4.03	246.4	36.0	12.2
IV.	No. 3,	238.4	85.7	200.1	14.45	4.90	28.91	9.80	83.9	12.1	4.11	233.5	33.7	11.4
		494.9	161.2	377.2	14.46	4.84	54.54	18.26	76.2	11.0	3.69	234.0	33.8	11.3
V.	No. 1,	259.5	86.6	196.6	14.32	4.75	28.16	9.33	75.8	10.9	3.60	227.0	32.5	10.8
		497.4	163.6	378.1	14.33	4.89	54.17	18.47	76.0	10.9	3.71	231.1	33.1	11.3
SANTA CLARA														
II.	No. 1,	255.4	85.2	375.0	14.19	5.00	53.22	18.75	146.8	20.8	7.34	440.2	62.5	22.0
		498.3	161.6	689.9	14.49	5.05	99.93	34.86	138.5	20.1	7.00	426.8	61.8	21.6
III.	No. 3,	269.3	83.3	326.9	14.54	5.12	47.52	16.75	121.4	17.6	6.22	392.4	57.0	20.1
		521.1	161.7	595.6	14.80	5.29	88.15	31.48	114.3	16.9	6.04	368.4	54.5	19.5
IV.	No. 1,	262.4	86.7	290.3	14.75	5.40	42.82	15.67	110.6	16.3	5.97	334.9	49.4	18.1
		509.9	163.6	544.5	14.85	5.36	80.87	29.16	106.8	15.9	5.72	332.8	49.4	17.8
V.	No. 3,	268.8	86.0	289.9	14.82	5.19	42.96	15.05	107.8	16.0	5.60	337.1	50.0	17.5
		499.1	162.7	546.1	14.76	5.24	80.63	28.63	109.4	16.2	5.74	335.6	49.6	17.6
EDITH														
I.	No. 1,	257.6	84.6	204.6	14.48	5.15	29.63	10.54	79.4	11.5	4.09	241.8	35.0	12.5
		501.4	162.0	388.1	14.50	5.11	56.29	19.82	77.4	11.2	3.95	239.6	34.7	12.2
II.	No. 3,	253.7	83.3	214.3	14.40	5.00	30.86	10.71	84.5	12.2	4.22	257.3	37.0	12.9
		485.4	149.6	347.5	14.74	5.31	51.22	18.47	71.6	10.6	3.81	232.3	34.2	12.3
III.	No. 1,	264.5	84.5	188.0	14.89	5.36	28.00	10.07	71.1	10.6	3.81	222.5	33.1	11.9
		522.4	163.2	362.7	14.62	5.26	53.01	19.07	69.4	10.1	3.65	222.2	32.5	11.7
IV.	No. 3,	264.0	85.7	186.9	14.68	5.28	27.43	9.87	70.8	10.4	3.74	218.1	32.0	11.5
		513.9	161.2	341.9	14.93	5.35	51.05	18.30	66.5	9.9	3.56	212.1	31.7	11.4
V.	No. 1,	270.6	86.6	159.7	14.95	5.30	23.88	8.46	59.0	8.8	3.13	184.5	27.6	9.8
		500.3	163.6	240.4	15.44	5.50	37.13	13.21	48.0	7.4	2.64	146.9	22.7	8.1

*In total ration. †In experimental portion of ration.

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow Experimental ration	Dry matter eaten*	Dry matter eaten†	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten: In entire ration: Milk	Total solids	Fat	In experimental feed: Milk	Total solids	Fat
		lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
	SONOMA													
I.	No. 3,	254.8	84.0	198.6	15.06	5.28	29.92	10.48	77.9	11.7	4.11	236.4	35.6	12.5
		494.6	159.3	388.3	14.95	5.22	58.04	20.26	78.5	11.7	4.10	243.7	36.4	12.7
II.	No. 1,	261.2	85.2	193.7	15.07	5.35	29.19	10.36	74.2	11.2	3.97	227.4	34.3	12.2
		499.0	161.6	359.6	15.33	5.48	55.12	19.71	72.1	11.0	3.95	222.5	34.1	12.2
III.	No. 3,	263.1	81.6	172.5	15.62	5.57	26.94	9.61	65.6	10.2	3.65	211.4	33.0	11.8
		519.8	161.7	327.3	15.47	5.62	50.62	18.40	63.0	9.7	3.54	202.4	31.3	11.4
	ZETA													
I.	No. 3,	235.1	78.8	246.7	14.32	4.70	35.33	11.59	104.9	15.0	4.93	313.1	44.8	14.7
		479.6	158.5	491.8	14.26	4.64	70.13	22.83	102.6	14.6	4.76	310.3	44.3	14.4
II.	No. 3,	252.0	83.2	253.7	14.45	4.72	36.65	11.98	100.7	14.5	4.75	304.9	44.0	14.4
		494.8	158.3	481.5	14.54	4.71	70.03	22.70	97.3	14.2	4.59	304.2	44.2	14.3
III.	No. 3,	261.0	82.4	249.4	14.64	4.77	36.50	11.19	95.6	14.0	4.56	302.7	44.3	14.5
		498.8	161.7	442.9	14.59	4.79	64.61	21.21	88.8	13.0	4.25	273.9	40.0	13.1
IV.	No. 3,	245.8	85.6	222.4	14.80	5.03	32.92	11.18	90.5	13.4	4.55	259.9	38.5	13.1
		495.4	161.2	436.5	14.66	4.87	63.99	21.27	88.1	12.9	4.29	270.8	39.7	13.2
V.	No. 3,	262.2	86.0	218.0	14.87	5.01	32.41	10.92	83.1	12.4	4.16	253.5	37.7	12.7
		498.6	162.7	423.4	14.66	4.92	62.08	20.81	84.9	12.5	4.17	260.2	38.2	12.8
	VERMONT UNA													
I.	No. 3,	248.1	84.0	279.6	14.63	5.33	40.89	14.89	112.7	16.5	6.00	332.9	48.7	17.7
		471.9	158.5	497.5	14.47	5.32	71.99	26.47	105.4	15.3	5.61	313.9	45.4	16.7
II.	No. 3,	249.1	80.6	257.8	14.48	5.29	37.33	13.65	103.5	15.0	5.48	319.8	46.3	16.9
		488.0	159.2	453.1	14.80	5.55	67.08	25.17	92.8	13.7	5.16	284.6	42.1	15.8
III.	No. 3,	255.5	83.2	209.3	14.88	5.65	31.15	11.82	81.9	12.3	4.63	251.6	37.4	14.2
		497.0	161.7	387.3	15.03	5.83	58.20	22.58	77.9	11.7	4.54	239.5	36.0	14.0
IV.	No. 3,	248.4	85.6	196.8	14.84	5.75	29.20	11.31	79.2	11.8	4.55	229.9	34.1	13.2
		486.6	161.2	405.0	15.23	5.83	61.67	23.62	83.2	12.7	4.85	251.2	38.3	14.7
V.	No. 3,	258.7	86.0	216.3	15.33	5.82	33.17	12.60	83.6	12.8	4.87	251.5	38.6	14.7
		484.6	162.7	397.8	15.12	5.71	60.15	22.71	82.1	12.4	4.69	244.5	37.0	14.0
	STEPHANIE													
I.	No. 1,	258.3	84.6	278.0	14.10	4.65	39.20	12.93	107.6	15.2	5.01	328.6	46.3	15.3
		499.7	162.8	536.5	13.94	4.54	74.77	24.36	107.4	15.0	4.88	329.6	45.9	15.0
II.	No. 4,	260.8	84.7	243.9	14.06	4.70	34.30	11.47	93.5	13.2	4.40	288.0	40.5	13.5
		496.1	158.3	465.0	14.12	4.62	65.65	21.49	93.7	13.2	4.33	293.7	41.5	13.6
III.	No. 1,	260.2	84.5	242.5	14.28	4.67	34.63	11.33	93.2	13.3	4.36	287.0	41.0	13.4
		511.5	163.2	491.7	14.17	4.62	69.67	22.71	96.1	13.6	4.44	301.3	42.7	13.9
IV.	No. 4,	259.1	85.5	249.0	14.08	4.70	35.06	11.70	96.1	13.5	4.52	291.2	41.0	13.7
		491.0	161.1	471.7	14.41	4.66	67.95	21.97	96.1	13.8	4.47	292.8	42.2	13.6
V.	No. 1,	262.8	86.5	256.7	14.14	4.60	36.27	11.81	97.7	13.8	4.49	296.8	41.9	13.7
		480.5	163.6	473.9	13.76	4.46	65.20	21.13	98.6	13.6	4.40	289.7	39.9	12.9

*In total ration. †In experimental portion of ration.

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

									Weight of products obtained per 100 lbs. of dry matter eaten					
									In entire ration			In experimental feed		
Period numbers	Name of cow Experimental ration	Dry matter eaten*	Dry matter eaten†	Milk	Total solids	Fat	Total solids	Fat	Milk	Total solids	Fat	Milk	Total solids	Fat
		lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
	YTTRIA													
I.	No. 4,	257.0	82.5	257.8	14.26	4.90	36.77	12.63	100.3	14.3	4.91	312.5	44.6	15.3
		506.6	161.4	509.0	14.22	4.82	72.36	24.53	100.5	14.3	4.84	315.4	44.8	15.2
II.	No. 1,	264.3	85.2	269.7	14.29	5.00	38.56	13.49	102.0	14.6	5.10	316.5	45.3	15.8
		511.7	161.6	518.4	14.60	4.95	75.67	25.66	101.3	14.8	5.01	320.8	46.8	15.9
III.	No. 4,	272.4	83.4	261.2	14.84	5.20	38.77	13.57	95.9	14.2	4.98	313.2	46.5	16.3
		516.3	155.4	481.6	15.02	5.35	72.35	25.76	93.3	14.0	4.99	309.9	46.6	16.6
IV.	No. 1,	264.2	86.6	254.6	14.75	5.20	37.54	13.24	96.4	14.2	5.01	294.0	43.4	15.3
		516.4	163.6	517.5	14.86	5.20	76.93	26.92	100.2	14.9	5.21	316.3	47.0	16.5
V.	No. 4,	270.0	85.6	274.2	15.04	5.20	41.24	14.26	101.5	15.3	5.28	320.3	48.2	16.7
		509.2	162.3	489.6	14.80	5.21	72.43	25.52	96.2	14.2	5.01	301.6	44.6	15.7
	EPSILON													
I.	No. 1,	248.1	84.6	144.8	14.42	4.64	20.88	6.72	58.4	8.4	2.71	171.2	24.7	7.9
		468.1	157.5	252.0	14.86	5.10	37.45	12.84	53.8	8.0	2.74	160.0	23.8	8.2
II.	No. 4,	245.6	81.2	136.4	15.08	5.25	20.57	7.16	55.5	8.4	2.92	168.0	25.3	8.8
		483.0	158.3	256.8	15.22	5.31	39.08	13.64	53.2	8.1	2.82	162.2	24.7	8.6
III.	No. 1,	229.9	77.5	98.1	16.02	6.14	15.72	6.02	42.7	6.8	2.62	126.2	20.3	7.8
		433.9	138.4	198.2	15.90	5.92	31.51	11.74	45.7	7.3	2.71	143.2	22.8	8.5
IV.	No. 4,	234.0	84.6	97.4	15.53	5.64	15.13	5.49	41.6	6.5	2.35	115.2	17.9	6.5
		478.1	159.3	200.9	15.45	5.70	31.05	11.45	42.0	6.5	2.39	126.1	19.5	7.2
V.	No. 1,	246.5	84.7	104.1	15.06	5.40	15.68	5.62	42.2	6.4	2.28	122.9	18.5	6.6
		462.6	163.6	194.9	15.51	5.82	30.23	11.35	42.1	6.5	2.45	119.1	18.5	6.9
	LADY PERUSIA													
I.	No. 4,	254.2	84.2	130.0	16.77	6.58	21.80	8.55	51.1	8.6	3.36	154.4	25.9	10.2
		495.5	160.5	240.2	16.66	6.51	40.02	15.64	48.5	8.1	3.16	149.6	24.9	9.7
II.	No. 1,	260.6	85.2	120.7	16.46	6.40	19.87	7.73	46.3	7.6	2.97	141.7	23.3	9.1
		501.5	161.6	227.1	16.76	6.61	38.05	15.01	45.3	7.6	2.99	140.5	23.5	9.3
III.	No. 4,	265.2	81.7	115.9	17.17	6.95	19.90	8.06	43.7	7.5	3.04	141.9	24.4	9.9
		513.9	161.6	241.0	17.07	6.86	41.15	16.54	46.9	8.0	3.22	149.1	25.5	10.2
IV.	No. 1,	260.2	86.6	135.2	16.83	6.77	22.75	9.15	52.0	8.7	3.52	156.2	26.3	10.6
		510.4	163.6	262.2	16.76	6.66	43.94	17.45	51.4	8.6	3.42	160.3	26.9	10.7
V.	No. 4,	265.5	85.6	133.9	16.57	6.64	22.19	8.89	50.4	8.4	3.35	156.5	25.9	10.4
		489.2	162.3	280.9	16.16	6.34	45.13	17.82	57.4	9.2	3.64	173.1	27.8	11.0
	SANTA ROSA													
I.	No. 4,	244.4	84.2	266.3	13.90	4.43	37.00	11.79	109.0	15.1	4.83	316.2	43.9	14.0
		490.2	161.4	502.0	13.67	4.32	68.64	21.70	102.4	14.0	4.43	311.0	42.5	13.4
II.	No. 4,	255.1	82.9	258.6	13.55	4.25	35.05	10.99	101.4	13.7	4.31	311.9	42.3	13.3
		499.8	159.2	449.8	13.71	4.40	61.69	19.77	90.0	12.3	3.96	282.5	38.7	12.4
III.	No. 4,	268.3	83.3	230.9	13.57	4.30	31.32	9.93	86.1	11.7	3.70	277.2	37.6	11.9
		518.8	160.7	451.1	13.66	4.39	61.61	19.78	87.0	11.9	3.81	280.7	38.3	12.3
IV.	No. 4,	263.6	85.4	229.3	13.52	4.43	31.03	10.15	87.0	11.8	3.85	268.5	36.8	11.9
		509.8	162.8	441.2	13.57	4.36	59.89	19.23	86.5	11.7	3.77	271.0	36.8	11.8
V.	No. 4,	267.3	85.5	227.5	13.69	4.45	31.15	10.12	85.1	11.7	3.79	266.1	36.4	11.8
		496.9	162.3	415.6	13.58	4.43	56.42	18.39	83.6	11.4	3.70	256.1	34.8	11.3

*In total ration. †In experimental portion of ration.

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow / Experimental ration	Dry matter eaten*	Dry matter eaten†	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten: In entire ration: Milk	In entire ration: Total solids	In entire ration: Fat	In experimental feed: Milk	In experimental feed: Total solids	In experimental feed: Fat
		lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
REBECCA														
I.	No. 4,	259.4	84.2	289.5	14.78	5.15	42.79	14.90	111.6	16.5	5.74	343.8	50.8	17.7
		506.7	161.4	534.3	14.64	5.17	78.22	27.64	105.4	15.4	5.46	331.0	48.5	17.1
II.	No. 4,	259.6	83.8	268.8	14.50	5.15	38.98	13.84	103.5	15.0	5.33	320.7	46.5	16.5
		500.6	158.3	509.0	15.00	5.43	76.33	27.69	101.7	15.2	5.53	321.6	48.2	17.5
III.	No. 4,	263.2	80.7	250.3	15.37	5.60	38.48	14.02	95.1	14.6	5.32	310.2	47.7	17.4
		509.2	161.6	480.7	15.15	5.56	72.84	26.74	94.4	14.3	5.25	297.4	45.1	16.5
IV.	No. 4,	259.5	85.4	252.3	14.70	5.25	37.08	13.25	97.2	14.3	5.11	295.5	43.4	15.5
		508.4	162.8	493.6	15.07	5.48	74.47	27.06	97.1	14.6	5.32	303.2	45.7	16.6
V.	No. 4,	263.6	85.5	266.6	15.24	5.60	40.62	14.93	101.1	15.4	5.66	311.8	47.5	17.5
		503.7	162.3	488.0	14.94	5.50	73.01	26.82	96.9	14.5	5.32	300.7	45.0	16.5
CHI														
I.	No. 1,	259.1	84.6	176.2	14.69	5.10	25.88	8.99	68.0	10.0	3.47	208.3	30.6	10.6
		506.1	162.8	338.1	14.80	5.32	50.04	18.00	66.8	9.9	3.56	207.7	30.7	11.1
II.	No. 5,	264.4	84.9	171.2	14.72	5.18	25.19	8.86	64.8	9.5	3.35	201.7	29.7	10.4
		510.0	161.4	333.9	14.86	5.30	49.62	17.69	65.5	9.7	3.47	206.9	30.7	11.0
III.	No. 1,	271.0	84.5	164.0	14.89	5.35	24.42	8.77	60.5	9.0	3.23	194.1	28.9	10.4
		525.7	163.2	319.3	15.04	5.49	48.02	17.54	60.7	9.1	3.34	195.6	29.4	10.7
IV.	No. 5,	263.2	85.6	166.1	14.75	5.27	24.49	8.76	63.1	9.3	3.33	194.1	28.6	10.2
		519.0	164.5	328.9	14.96	5.40	49.20	17.77	63.4	9.5	3.42	200.0	29.9	10.8
V.	No. 1,	271.4	86.6	172.8	15.02	5.46	25.95	9.43	63.7	9.6	3.48	199.5	30.0	10.9
		507.4	163.6	309.7	14.97	5.60	46.36	17.36	61.0	9.1	3.42	189.3	28.3	10.6
LUCERNE														
I.	No. 5,	254.0	84.4	183.3	15.17	5.30	27.81	9.71	72.2	11.0	3.82	217.2	33.0	11.5
		502.0	161.6	347.3	15.31	5.52	53.15	19.17	69.2	10.6	3.82	214.9	32.9	11.9
II.	No. 1,	261.1	83.4	167.7	15.36	5.68	25.76	9.52	64.2	9.9	3.65	201.1	30.9	11.4
		507.8	160.7	308.5	15.74	5.82	48.55	17.96	60.8	9.6	3.54	192.0	30.2	11.2
III.	No. 5,	268.5	82.4	169.3	16.06	6.05	27.19	10.25	63.1	10.1	3.82	205.5	33.0	12.4
		503.7	160.0	315.1	15.87	6.00	49.99	18.92	62.6	9.9	3.76	196.9	31.2	11.8
IV.	No. 1,	259.9	86.6	153.7	16.30	6.30	25.06	9.68	59.1	9.6	3.72	177.5	28.9	11.2
		506.2	163.6	292.5	15.91	6.08	46.54	17.79	57.8	9.2	3.51	178.8	28.4	10.9
V.	No. 5,	265.9	83.5	170.0	15.80	6.00	26.86	10.20	63.9	10.1	3.84	203.6	32.2	12.2
		510.7	164.3	338.4	15.50	5.91	52.43	20.00	66.2	10.3	3.92	206.0	31.9	12.2
FATIMA														
I.	No. 1,	241.4	84.6	145.1	16.08	6.02	23.33	8.74	60.1	9.7	3.62	171.5	27.6	10.3
		476.6	162.8	269.2	16.31	6.20	43.90	16.68	56.4	9.2	3.49	165.3	27.0	10.3
II.	No. 5,	241.5	82.2	151.5	16.32	6.35	24.72	9.62	62.7	10.2	3.98	184.3	30.1	11.7
		477.6	161.4	289.1	16.23	6.24	46.90	18.03	60.5	9.8	3.78	179.1	29.1	11.2
III.	No. 1,	252.0	84.5	135.0	16.62	6.60	22.43	8.91	53.6	8.9	3.54	159.8	26.5	10.5
		483.1	162.3	255.4	16.31	6.35	41.67	16.21	52.9	8.6	3.36	157.4	25.7	10.0
IV.	No. 5,	246.6	85.6	142.0	16.48	6.54	23.40	9.28	57.6	9.5	3.76	165.9	27.3	10.8
		474.7	164.5	276.6	16.45	6.53	45.49	18.07	58.3	9.6	3.81	168.1	27.7	11.0
V.	No. 1,	247.9	86.6	143.7	16.30	6.28	23.42	9.02	58.0	9.5	3.64	165.9	27.0	10.4
		443.4	162.7	260.5	16.46	6.58	42.87	17.13	58.8	9.7	3.86	160.1	26.4	10.5

*In total ration. †In experimental portion of ration.

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow / Experimental ration	Dry matter eaten*	Dry matter eaten†	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten: In entire ration: Milk	Total solids	Fat	In experimental feed: Milk	Total solids	Fat
		lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
	SARNIA													
I.	No. 5,	257.8	84.4	187.2	14.40	4.70	26.95	8.80	72.6	10.5	3.41	221.8	31.9	10.4
		494.9	160.7	336.7	14.20	4.60	47.79	15.46	68.0	9.7	3.12	209.5	29.7	9.6
II.	No. 5,	255.3	84.0	153.5	13.87	4.44	21.29	6.81	60.1	8.3	2.67	182.7	25.3	8.1
		492.6	161.4	287.9	14.30	4.68	41.18	13.48	58.4	8.4	2.74	178.4	25.5	8.4
III.	No. 5,	254.1	82.3	140.9	14.50	4.85	20.42	6.84	55.5	8.0	2.69	171.2	24.8	8.3
		478.3	160.0	275.0	14.50	4.93	39.87	13.56	57.5	8.3	2.84	171.9	24.9	8.5
IV.	No. 5,	244.7	83.8	126.6	14.75	5.20	18.67	6.58	51.7	7.6	2.69	151.1	22.3	7.9
		490.0	164.5	248.9	14.57	5.15	36.29	12.78	50.8	7.4	2.61	151.3	22.1	7.8
V.	No. 5,	265.8	86.2	138.0	14.46	5.00	19.95	6.90	51.9	7.5	2.60	160.1	23.1	8.0
		509.5	164.3	273.0	14.32	4.99	39.10	13.63	53.6	7.7	2.68	166.2	23.8	8.3
	URSULA													
I.	No. 5,	.....	105.6	213.6	15.17	5.34	32.40	11.41	.....	....	....	202.3	30.7	10.8
		539.4	201.9	405.3	14.83	5.16	60.08	20.91	75.1	11.1	3.88	200.7	29.8	10.4
II.	No. 5,	279.0	105.2	204.3	14.59	5.10	29.80	10.42	73.2	10.7	3.74	194.2	28.3	9.9
		545.4	201.7	393.4	14.77	5.20	58.11	20.44	72.1	10.7	3.75	195.1	28.8	10.1
III.	No. 5,	282.2	105.1	199.0	15.18	5.50	30.21	10.94	69.1	10.5	3.80	189.3	28.7	10.4
		546.3	203.2	365.6	14.72	5.24	53.82	19.14	66.9	9.9	3.50	179.8	26.5	9.4
IV.	No. 5,	275.2	106.9	182.0	15.01	5.55	27.32	10.10	66.1	9.9	3.67	170.2	25.6	9.4
		551.4	205.6	366.8	14.59	5.33	53.51	19.56	66.5	9.7	3.55	178.4	26.0	9.5
V.	No. 5,	287.7	107.8	196.3	14.90	5.45	29.24	10.70	68.2	10.2	3.72	182.1	27.1	9.9
		547.3	205.4	396.5	14.85	5.49	58.90	21.77	72.5	10.8	3.98	193.0	28.7	10.6
	CONSTANCE													
I.	No. 1,	233.9	83.7	195.6	15.28	5.70	29.89	11.15	83.6	12.8	4.77	233.6	35.7	13.3
		396.0	155.8	321.2	15.43	5.99	49.57	19.28	81.1	12.5	4.86	206.2	31.8	12.3
II.	No. 6,	201.2	68.3	154.0	15.22	5.95	23.44	9.17	76.5	11.7	4.56	225.5	34.3	13.4
		431.2	160.3	319.3	15.44	6.03	49.28	19.26	74.1	11.4	4.47	199.2	30.7	12.0
III.	No. 1,	235.1	84.5	165.5	15.24	5.80	25.22	9.60	70.4	10.7	4.08	195.9	29.8	11.4
		417.1	158.8	289.9	15.43	6.01	44.72	17.41	69.5	10.7	4.17	182.5	28.2	11.0
IV.	No. 6,	229.6	87.3	141.0	15.66	6.15	22.08	8.67	61.4	9.6	3.78	161.5	25.3	9.9
		429.3	162.5	279.7	15.98	6.23	44.69	17.42	65.1	10.4	4.06	172.1	27.5	10.7
V.	No. 1,	228.0	86.7	151.6	15.34	5.88	23.26	8.91	66.5	10.2	3.91	174.9	26.8	10.3
		394.7	161.8	244.8	15.61	6.12	38.21	14.98	62.0	9.7	3.80	151.3	23.6	9.3
	ELSA													
I.	No. 6,	255.7	84.5	357.0	13.98	4.75	49.91	15.95	139.6	19.5	6.63	422.5	59.1	20.1
		505.9	162.3	696.0	14.09	4.92	98.07	34.27	137.6	19.4	6.77	428.8	60.4	21.1
II.	No. 1,	265.5	85.2	348.4	14.12	4.80	49.16	16.72	131.2	18.5	6.30	408.9	57.7	19.6
		509.4	161.6	593.6	14.39	5.09	85.42	30.24	116.5	16.8	5.94	367.3	52.9	18.7
III.	No. 6,	272.7	84.8	310.7	14.65	5.20	45.51	16.16	113.9	16.7	5.93	366.4	53.7	19.1
		518.2	163.0	574.9	14.63	5.25	84.12	30.21	110.9	16.2	5.83	352.7	51.6	18.5
IV.	No. 1,	265.1	86.8	292.9	14.36	5.05	42.06	14.78	110.5	15.9	5.58	337.4	48.5	17.0
		514.1	163.6	560.3	14.58	5.22	81.69	29.24	109.0	15.9	5.69	342.5	49.9	17.9
V.	No. 6,	273.6	87.2	301.8	14.65	5.25	44.21	15.85	110.3	16.2	5.79	346.1	50.7	18.2
		505.3	164.3	551.2	14.70	5.33	81.05	29.39	109.1	16.0	5.82	335.5	49.3	17.9

*In total ration. †In experimental portion of ration.

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow / Experimental ration	Dry matter eaten*	Dry matter eaten†	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten: In entire ration: Milk	Total solids	Fat	In experimental feed: Milk	Total solids	Fat
		lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
	GAMMA													
I.	No. 1,	254.2	84.6	205.5	16.30	6.23	33.49	12.80	80.8	13.2	5.04	242.9	39.6	15.1
		497.4	162.8	417.4	15.96	6.02	66.62	25.13	83.9	13.4	5.05	256.4	40.9	15.4
II.	No. 6,	263.3	85.2	233.2	15.88	6.00	37.03	14.00	88.6	14.1	5.32	273.7	43.5	16.4
		506.9	162.1	438.2	15.80	5.92	69.29	25.95	86.4	13.7	5.12	270.3	42.7	16.0
III.	No. 1,	271.5	84.5	215.9	16.36	6.35	35.33	13.71	79.5	13.0	5.05	255.5	41.8	16.2
		526.3	163.2	423.8	15.85	5.96	67.19	25.27	80.5	12.8	4.80	259.7	41.2	15.5
IV.	No. 6,	262.2	87.3	222.2	15.63	5.80	34.72	12.89	84.7	13.2	4.92	254.5	39.8	14.8
		510.3	162.5	445.8	15.85	5.98	70.65	26.66	87.4	13.8	5.22	274.3	43.5	16.4
V.	No. 1,	270.9	86.7	233.8	16.00	6.01	37.42	14.04	86.3	13.8	5.18	269.7	43.2	16.2
		509.4	163.6	419.5	15.74	6.02	66.01	25.26	82.3	13.0	4.96	256.4	40.4	15.4
	LAVENDER													
I.	No. 1,	255.5	84.6	205.9	14.84	5.39	30.55	11.10	80.0	12.0	3.34	243.4	36.1	13.1
		501.5	162.8	377.3	14.85	5.27	56.04	19.88	75.2	11.2	3.96	231.7	34.4	12.2
II.	No. 1,	257.5	85.2	190.7	14.95	5.46	28.50	10.42	74.0	11.1	4.05	223.8	33.5	12.2
		496.8	161.6	334.2	15.05	5.50	50.31	18.39	67.3	10.1	3.70	206.8	31.1	11.4
III.	No. 1,	267.3	83.6	163.2	15.87	6.35	25.90	10.37	61.1	9.7	3.88	195.2	31.0	12.4
		501.0	163.2	307.0	15.18	5.72	46.60	17.55	61.3	9.3	3.50	188.1	28.6	10.8
IV.	No. 1,	256.1	86.7	149.1	15.23	5.85	22.70	8.73	58.2	8.9	3.41	172.0	26.2	10.1
		506.1	163.6	300.4	15.00	5.62	45.05	16.88	59.3	8.9	3.34	183.6	27.5	10.3
V.	No. 1,	267.8	86.6	166.9	14.82	5.50	24.72	9.18	62.3	9.2	3.43	192.7	28.5	10.6
		511.3	163.6	326.8	14.75	5.53	48.21	18.06	63.9	9.4	3.53	199.7	29.5	11.0
	VIVIAN													
I.	No. 1,	257.6	84.6	285.9	13.87	4.58	39.65	13.08	111.1	15.4	5.08	338.0	46.9	15.5
		501.5	162.8	560.6	13.61	4.39	76.27	24.62	111.8	15.2	4.91	344.3	46.8	15.1
II.	No. 1,	261.0	85.2	290.1	13.41	4.33	38.91	12.55	111.1	14.9	4.81	340.5	45.7	14.7
		505.6	161.6	533.6	13.91	4.49	74.20	23.97	105.5	14.7	4.74	330.2	45.9	14.8
III.	No. 1,	268.6	84.5	262.6	13.94	4.50	36.59	11.81	97.8	13.6	4.40	310.8	43.3	14.0
		508.0	163.2	474.4	13.80	4.52	65.45	21.43	93.4	12.9	4.22	290.7	40.1	13.1
IV.	No. 1,	261.5	86.7	237.9	13.79	4.60	32.80	10.94	91.0	12.5	4.18	274.5	37.8	12.6
		504.1	163.6	474.6	14.05	4.49	66.66	21.30	94.2	13.2	4.23	290.1	40.7	13.0
V.	No. 1,	264.1	86.6	249.3	14.02	4.57	34.96	11.40	94.4	13.2	4.32	287.9	40.4	13.2
		492.0	163.6	446.9	13.78	4.61	61.58	20.61	90.8	12.5	4.19	273.2	37.6	12.6
	LAURA													
I.	No. 6,	258.2	84.5	237.8	14.58	5.10	34.67	12.13	92.1	13.4	4.70	281.5	41.0	14.4
		478.5	158.8	430.7	14.25	4.81	61.38	20.73	90.0	12.8	4.33	271.0	38.6	13.1
II.	No. 6,	251.7	85.2	213.8	14.64	5.10	31.30	10.90	84.9	12.0	4.33	250.9	36.7	12.8
		494.9	162.1	395.6	14.39	4.83	56.91	19.09	79.9	11.5	3.86	244.0	35.1	11.8
III.	No. 6,	266.0	84.8	201.5	14.65	5.05	29.48	10.17	75.6	11.1	3.82	237.3	34.8	12.0
		519.4	163.0	388.5	14.73	5.08	57.24	19.73	74.8	11.0	3.80	238.4	35.1	12.1
IV.	No. 7,	263.9	86.6	172.1	15.46	5.79	26.61	9.97	65.2	10.1	3.78	198.7	30.7	11.5
		510.4	162.5	365.4	14.67	5.14	53.59	18.80	71.6	10.5	3.68	224.8	33.0	11.6
V.	No. 6,	269.1	87.3	197.2	14.65	5.17	28.90	10.21	73.3	10.7	3.79	225.9	33.1	11.7
		509.4	164.3	364.8	14.33	4.97	52.28	18.13	71.6	10.3	3.56	222.0	31.8	11.0

*In total ration. †In experimental portion of ration.

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow / Experimental ration	Dry matter eaten*	Dry matter eaten†	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten					
									In entire ration			In experimental feed		
									Milk	Total solids	Fat	Milk	Total solids	Fat
		lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
	CASSANDRA													
I.	No. 1,	250.4	84.6	227.1	15.07	5.18	34.23	11.76	90.7	13.7	4.70	268.5	40.5	13.9
		483.8	162.8	439.2	14.97	5.18	65.76	22.68	90.8	13.6	4.69	269.7	40.4	13.9
II.	No. 1,	249.9	83.5	227.6	14.81	5.10	33.70	11.61	91.1	13.5	4.65	272.6	40.4	13.9
		491.9	160.7	438.9	15.18	5.32	66.65	23.37	89.2	13.6	4.75	273.1	41.5	14.5
III.	No. 1,	261.0	84.5	220.7	15.40	5.45	33.98	12.03	84.5	13.0	4.61	261.2	40.2	14.2
		492.4	163.2	409.1	15.39	5.53	62.97	22.62	83.1	12.8	4.59	250.7	38.6	13.9
IV.	No. 1,	248.6	85.8	207.8	15.22	5.45	31.63	11.32	83.6	12.7	4.55	242.3	36.9	13.2
		489.2	162.7	418 2	15.54	5.67	64.99	23.70	85.5	13.3	4.84	257.0	39.9	14.5
V.	No. 1,	259.1	86.6	222.8	15.35	5.40	34.19	12.04	86.0	13.2	4.65	257.3	39.5	13.9
		485.8	163.6	386.9	15.16	5.39	58.63	20.84	79.6	12.1	4.29	236.5	35.8	12.7
	ALTA													
I.	No. 1,	256.5	84.6	258.2	15.02	5.35	38.79	13.81	100.7	15.1	5.38	305.2	45.9	16.3
		498.4	160.2	492.8	14.74	5.20	72.64	25.60	98.9	14.6	5.14	307.6	45.3	16.0
II.	No. 7,	254.7	82.2	242.8	14.60	5.15	35.46	12.50	95.3	13.9	4.91	295.4	43.1	15.2
		500.1	159.4	444.0	14.70	5.23	65.28	23.22	88.8	13.1	4.64	278.6	41.0	14.6
III.	No. 1,	268.4	82.7	219.9	14.93	5.43	32.84	11.93	81.9	12.2	4.45	265.9	39.7	14.4
		510.9	160.5	415.2	14.77	5.34	61.34	22.18	81.3	12.0	4.34	258.7	38.2	13.8
IV.	No. 7,	256.7	85.7	201.6	14.72	5.30	29.67	10.68	78.5	11.6	4.16	235.1	34.6	12.5
		495.1	159.3	356.0	14.69	5.27	52.29	18.77	71.9	10.6	3.79	223.5	32.8	11.8
V.	No. 1,	252.6	78.5	182.4	14.92	5.34	27.22	9.75	72.2	10.8	3.86	232.4	34.7	12.4
		487.3	160.0	364.5	14.91	5.38	54.33	19.60	74.8	11.1	4.02	227.8	34.0	12.3
	ADELAIDE													
I.	No. 7,	248.5	82.8	175.2	14.68	5.10	25.71	8.93	70.5	10.3	3.59	211.6	31.1	10.8
		374.1	115.4	245.0	15.50	6.02	37.97	14.75	65.5	10.2	3.94	212.3	32.9	12.8
II.	No. 1,	233.6	72.8	134.9	15.72	6.20	21.21	8.36	57.7	9.1	3.58	185.3	29.1	11.5
		462.3	151.9	273.3	15.40	5.90	42.08	16.12	59.1	9.1	3.49	179.9	27.7	10.6
III.	No. 7,	205.3	58.5	120.9	15.72	6.20	19.01	7.50	58.9	9.3	3.65	206.7	32.5	12.8
		476.7	152.4	283.8	14.83	5.49	42.10	15.59	59.5	8.8	3.27	186.3	27.6	10.2
IV.	No. 1,	207.5	67.7	109.8	14.84	5.65	16.30	6.21	52.9	7.9	2.99	162.2	24.1	9.2
		478.0	163.6	270.6	14.92	5.62	40.40	15.21	56.6	8.5	3.18	165.4	24.7	9.3
V.	No. 7,	253.2	86.0	151.4	14.50	5.25	21.96	7.95	59.8	8.7	3.14	176.0	25.5	9.2
		480.4	163.4	291.8	14.31	5.16	41.76	15.06	60.7	8.7	3.14	178.6	25.6	9.2
	STAR BRIGHT													
I.	No. 1,	253.9	84.6	207.4	15.72	5.80	32.60	12.02	81.7	12.8	4.73	245.2	38.5	14.2
		498.2	162.8	373.9	15.47	5.68	57.95	21.22	75.1	11.6	4.26	229.7	35.5	13.0
II.	No. 7,	261.7	84.9	196.2	15.01	5.27	29.45	10.34	75.0	11.3	3.95	231.1	34.7	12.2
		510.6	161.2	358.9	15.49	5.59	55.59	20.06	70.3	10.9	3.93	222.6	34.5	12.4
III.	No. 1,	270.6	81.9	176.5	15.95	5.90	28.16	10.41	65.2	10.4	3.85	215.5	34.4	12.7
		524.4	163.2	332.5	15.42	5.61	51.29	18.66	63.4	9.8	3.56	203.7	31.4	11.4
IV.	No. 7,	263.9	86.6	172.1	15.46	5.79	26.61	9.97	65.2	10.1	3.78	198.7	30.7	11.5
		514.4	163.7	332.1	15.64	5.85	51.95	19.43	64.6	10.1	3.77	202.9	31.7	11.9
V.	No. 1,	271.2	86.6	176.2	15.61	5.74	27.51	10.12	65.0	10.1	3.73	203.5	31.8	11.7
		449.2	139.6	264.8	15.26	5.72	40.42	15.16	59.0	9.0	3.37	189.7	29.0	10.9

*In total ration. †In experimental portion of ration.

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow Experimental ration	Dry matter eaten*	Dry matter eaten†	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten					
									In entire ration			In experimental feed		
									Milk	Total solids	Fat	Milk	Total solids	Fat
		lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
	YEMASSEE													
I.	No. 1,	256.8	84.6	256.6	13.96	4.60	35.83	11.81	99.9	14.0	4.60	303.3	42.4	14.0
		498.0	162.8	490.6	13.86	4.56	68.00	22.37	98.5	13.7	4.49	301.3	41.8	13.7
II.	No. 1,	269.4	85.2	256.2	13.62	4.45	34.91	11.40	95.1	13.0	4.23	300.7	41.0	13.4
		498.1	161.6	498.3	14.18	4.67	70.66	23.26	100.0	14.2	4.67	308.3	43.7	14.4
III.	No. 1,	262.6	84.5	253.5	14.49	4.90	36.73	12.42	96.5	14.0	4.73	300.0	43.5	14.7
		509.7	163.2	484.5	14.12	4.68	68.45	22.66	95.1	13.4	4.45	296.9	41.9	13.9
IV.	No. 1,	262.6	86.7	249.5	14.18	4.75	35.39	11.85	95.0	13.5	4.51	287.8	40.8	13.7
		502.3	163.6	496.2	14.42	4.87	71.53	24.16	98.8	14.2	4.81	30.33	43.7	14.8
V.	No. 1,	265.0	86.6	266.3	14.30	4.65	38.08	12.39	100.5	14.4	4.68	307.5	44.0	14.3
		493.6	163.6	482.3	14.05	4.73	67.77	22.80	97.7	13.7	4.62	294.8	41.4	13.9
	MU													
I.	No. 1,	260.5	84.6	216.2	15.06	5.43	32.70	11.78	83.4	12.6	4.52	256.7	38.7	13.9
		510.5	162.8	435.7	14.76	5.21	64.30	22.70	85.3	12.6	4.45	267.6	29.5	13.9
II.	No. 1,	270.5	85.2	224.9	14.45	5.05	32.51	11.35	83.2	12.0	4.20	263.9	38.2	13.3
		514.4	161.6	418.9	14.61	5.09	61.19	21.33	81.4	11.9	4.15	259.2	37.9	13.2
III.	No. 1,	271.0	84.5	211.8	14.93	5.32	31.63	11.27	78.2	11.7	4.16	250.7	37.4	13.3
		523.9	163.2	411.8	15.11	5.52	62.22	22.73	78.6	11.9	4.34	252.3	38.1	13.9
IV.	No. 1,	265.8	86.7	228.7	14.93	5.67	34.15	12.97	86.0	12.8	4.88	263.8	39.4	15.0
		519.4	163.6	424.6	14.90	5.41	63.28	22.97	81.8	12.2	4.42	259.5	38.7	14.0
V.	No. 1,	272.7	86.6	232.2	14.87	5.38	34.60	12.49	85.2	12.7	4.58	268.3	40.0	14.4
		518.5	163.6	419.4	14.67	5.32	61.51	22.33	80.9	11.9	4.31	256.4	37.6	13.7
	MERMAID													
I.	No. 1,	257.0	83.7	206.4	16.37	6.35	33.79	13.10	80.3	13.1	5.10	246.6	40.4	15.7
		512.2	162.8	392.9	16.27	6.31	63.94	24.79	76.7	12.5	4.84	241.3	39.3	15.2
II.	No. 1,	267.4	85.2	208.1	15.92	6.12	33.14	12.74	77.8	12.4	4.76	244.3	38.9	15.0
		509.8	161.6	401.1	16.03	6.19	64.28	24.82	78.7	12.6	4.87	248.2	39.8	15.4
III.	No. 1,	271.2	84.5	213.3	15.97	6.10	34.06	13.01	78.6	12.6	4.80	252.4	40.3	15.4
		518.2	162.3	382.9	16.04	6.31	61.40	24.16	73.9	11.8	4.66	235.9	37.8	14.9
IV.	No. 1,	263.0	86.7	176.2	16.00	6.25	28.19	11.02	67.0	10.7	4.19	203.2	32.5	12.7
		512.0	163.6	360.5	16.13	6.29	58.14	22.65	70.4	11.4	4.42	220.4	35.5	13.8
V.	No. 1,	270.8	86.6	183.8	15.83	6.15	29.09	11.30	67.9	10.7	4.17	212.3	33.6	13.1
		515.0	163.6	371.7	15.85	6.10	58.91	22.67	72.2	11.4	4.40	227.2	36.0	13.9
	ROSEL													
I.	No. 1,	254.8	84.6	246.6	14.39	4.80	35.49	11.83	96.8	13.9	4.64	291.5	41.9	14.0
		497.0	162.8	441.2	14.35	4.86	63.33	21.44	88.8	12.7	4.31	271.0	38.9	13.2
II.	No. 1,	259.8	85.2	239.8	14.16	4.73	33.96	11.33	92.3	13.1	4.36	281.5	39.9	13.3
		494.5	161.6	416.5	14.34	4.82	59.74	20.07	84.2	12.1	4.06	257.8	37.0	12.4
III.	No. 1,	274.6	84.5	212.3	14.28	4.81	30.33	10.20	77.3	11.0	3.71	251.3	35.9	12.1
		492.4	163.2	395.3	14.34	4.92	56.67	19.44	80.3	11.5	3.95	242.2	34.7	11.9
IV.	No. 1,	255.0	86.7	194.1	14.43	5.00	28.00	9.70	76.1	11.0	3.80	223.9	32.3	11.2
		492.9	163.6	377.2	14.61	5.04	55.10	19.00	76.5	11.2	3.85	230.6	33.7	11.6
V.	No. 1,	263.2	86.6	190.3	14.92	5.03	28.39	9.57	72.3	10.8	3.64	219.7	32.8	11.1
		500.6	163.6	348.9	14.90	5.08	51.97	17.72	69.7	10.4	3.54	213.3	31.8	10.8

*In total ration. †In experimental portion of ration.

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow Experimental ration	Dry matter eaten*	Dry matter eaten†	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten: In entire ration: Milk	Total solids	Fat	In experimental feed: Milk	Total solids	Fat
		lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
JANICE														
I.	No. 7,	248.3	84.6	166.2	15.00	5.10	24.93	8.48	66.9	10.0	3.42	196.5	29.5	10.0
		476.7	162.1	312.3	14.86	5.03	46.41	15.70	65.5	9.7	3.29	192.6	28.6	9.7
II.	No. 7,	243.4	83.1	158.1	14.73	5.00	23.30	7.91	65.0	9.6	3.25	190.3	28.0	9.5
		487.6	161.2	301.7	15.00	5.14	45.27	15.51	61.9	9.3	3.18	187.2	28.1	9.6
III.	No. 7,	259.0	83.7	145.3	15.22	5.30	22.12	7.70	56.1	8.5	2.97	173.6	26.4	9.2
		494.6	162.1	275.2	15.00	5.17	41.31	14.24	55.6	8.4	2.88	169.8	25.5	8.8
IV.	No. 7,	264.6	86.6	140.3	14.67	5.00	20.58	7.02	53.0	7.8	2.65	162.0	23.8	8.1
		509.3	163.7	270.3	14.83	5.10	40.09	13.78	53.1	7.9	2.71	165.1	24.5	8.4
V.	No. 7,	265.7	86.0	141.8	14.84	5.20	21.04	7.38	53.4	7.9	2.78	164.8	24.5	8.6
		485.5	163.4	242.0	14.64	5.12	35.43	12.38	49.8	7.3	2.55	148.1	21.7	7.6
JUDITH														
I.	No. 6,	246.8	84.5	157.5	16.07	6.20	25.30	9.77	63.8	10.3	3.96	186.4	29.9	10.6
		447.2	148.2	287.2	16.26	6.43	46.71	18.45	64.2	10.4	4.13	193.8	31.5	12.5
II.	No. 7,	251.0	84.9	155.5	15.82	6.14	24.61	9.55	62.0	9.8	3.82	183.2	29.0	11.3
		485.5	160.3	285.3	16.13	6.32	46.02	18.04	58.8	9.5	3.72	178.0	28.7	11.3
III.	No. 6,	255.7	83.0	148.5	16.77	6.75	24.91	10.02	58.1	9.7	3.92	178.9	30.0	12.1
		476 7	157.7	275.9	16.50	6.64	45.53	18.31	57.9	9.6	3.84	175.0	28.9	11.6
IV.	No. 7,	256.5	86.6	147.4	16.15	6.40	23.81	9.43	57.5	9.3	3.68	170.2	27.5	10.9
		497.2	163.7	285.6	15.90	6.22	45.42	17.77	57.4	9.1	3.57	174.5	27.7	10.9
V.	No. 6,	249.4	87.2	160.1	15.95	6.25	25.54	10.01	64.2	10.2	4.02	183.6	29.3	11.5
		478.5	164.3	318.6	16.03	6.32	51.06	20.10	66.6	10.7	4.20	193.9	31.1	12.2
YUBA														
I	No. 7,													
		504.7	158.5	553.2	13.52	4.49	74.81	24.83	109.6	14.8	4.92	349.2	47.2	15.[illegible]
II.	No. 6,	268.2	85.2	281.5	13.60	4.45	38.28	12.53	105.0	14.3	4.68	330.4	44.9	14.7
		515.7	162.1	498.5	13.71	4.58	68.33	22.81	96.7	13.3	4.42	307.5	42.2	14.1
III.	No. 7,	272.0	83.8	238.6	13.66	4.58	32.60	10.92	87.7	12.0	4.01	284.7	38.9	13.0
		526.9	162.1	456.7	13.76	4.63	62.82	21.16	86.7	11.9	4.02	281.7	38.8	13.1
IV.	No. 6,	267.4	87.3	241.2	14.15	4.93	34.13	11.88	90.2	12.8	4.44	276.3	39.1	13.6
		517.0	162.5	462.1	14.27	4.94	65.92	22.84	89.4	12.8	4.42	284.4	40.6	14.1
V.	No. 7,	272.0	86.1	243.9	14.03	4.79	34.23	11.69	89.7	12.6	4.30	283.3	39.8	13.6
		515.7	163.4	466.7	14.16	4.94	66.08	23.05	90.5	12.8	4.47	285.6	40.4	14.1
ZILLAH														
I.	No. 7,	246.0	83.7	254.7	13.76	4.32	35.05	11.01	103.5	14.2	4.48	304.3	41.9	13.1
		477.1	160.3	442.4	13.78	4.43	60.97	19.61	92.7	12.8	4.11	276.0	38.0	12.2
II.	No. 6,	250.5	85.2	229.9	13.62	4.20	31.32	9.66	91.8	12.5	3.86	269.8	36.8	11.3
		478.9	159.5	441.4	13.78	4.31	60.79	19.02	92.2	12.7	3.97	276.7	38.1	11.9
III.	No. 7,	257.4	83.8	229.7	13.79	4.38	31.68	10.05	89.2	12.3	3.90	274.1	37.8	12.0
		493.7	160.3	435.7	13.76	4.36	59.95	18.98	88.2	12.1	3.84	271.8	37.4	11.8
IV.	No. 6,	254.1	87.3	231.5	13.90	4.40	32.18	10.18	91.1	12.7	4.01	265.2	36.9	11.7
		492.2	162.5	474.6	13.78	4.30	65.37	20.40	96.4	13.3	4.14	292.1	40.2	12.6
V.	No. 7,	252.0	82.6	253.3	13.60	4.13	34.45	10.46	100.5	13.7	4.15	306.7	41.7	12.7
		465.8	159.8	432.7	13.75	4.43	59.50	19.18	92.9	12.8	4.12	270.8	37.2	12.0

*In total ration. †In experimental portion of ration.

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

Period numbers	Name of cow Experimental ration	Dry matter eaten*	Dry matter eaten†	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter eaten: In entire ration: Milk	Total solids	Fat	In experimental feed: Milk	Total solids	Fat
		lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
POMONA														
I.	No. 6,	231.2	84.5	145.8	14.62	5.34	21.32	7.79	63.1	9.2	3.37	172.6	25.2	9.2
		455.7	158.8	263.3	14.52	5.37	38.23	14.13	57.8	8.4	3.10	165.8	24.1	8.9
II.	No. 6,	231.7	85.2	132.5	14.31	5.32	18.96	7.05	57.2	8.2	3.04	155.5	22.2	8.3
		447.6	160.3	235.3	14.61	5.53	34.37	13.00	52.6	7.7	2.90	146.8	21.4	8.1
III.	No. 6,	234.0	83.0	119.4	15.00	5.74	17.91	6.86	51.0	7.7	2.93	143.8	21.6	8.3
		463.8	160.4	216.4	14.86	5.67	32.15	12.27	46.7	6.9	2.65	134.9	20.1	7.6
IV.	No. 6,	246.2	87.4	101.8	14.94	5.75	15.21	5.85	41.3	6.2	2.38	116.5	17.4	6.7
		475.1	162.5	186.2	15.21	5.63	28.23	10.49	39.2	5.9	2.21	114.6	17.4	6.5
V.	No. 6,	250.8	87.3	84.1	15.81	6.10	13.30	5.13	33.5	5.3	2.05	96.3	15.2	5.8
		472.8	162.5	155.2	15.34	5.60	23.80	8.69	32.8	5.0	1.84	95.5	14.6	5.3
MYRTLE														
I.	No. 7,	252.8	84.6	242.3	15.46	5.45	37.46	13.20	95.8	14.8	5.22	286.5	44.3	15.6
		484.9	162.1	429.2	15.39	5.54	66.05	23.76	88.5	13.6	4.90	264.7	40.7	14.7
II.	No. 7,	253.5	84.9	214.6	15.38	5.65	33.00	12.12	84.7	13.0	4.78	252.8	38.9	14.3
		486.3	161.2	402.6	15.75	5.72	63.40	23.02	82.8	13.0	4.73	249.8	39.3	14.3
III.	No. 7,	256.2	82.8	197.0	15.91	5.77	31.34	11.37	76.9	12.2	4.44	237.9	37.9	13.7
		502.1	162.1	385.1	15.69	5.76	60.42	22.16	76.7	12.0	4.41	237.6	37.3	13.7
IV.	No. 7,	256.5	86.6	195.5	15.63	5.90	30.55	11.53	76.2	11.9	4.50	225.8	35.3	13.3
		495.9	163.7	383.3	15.86	5.92	60.79	22.69	77.3	12.3	4.58	234.1	37.1	13.9
V.	No. 7,	259.9	86.0	207.5	15.85	5.90	32.88	12.25	79.8	12.7	4.71	241.3	38.2	14.2
		487.2	163.4	372.5	15.85	5.98	59.03	22.27	76.5	12.1	4.57	228.0	36.1	13.6

*In total ration. †In experimental portion of ration.

NOTE.—The first and every alternate horizontal line thereafter gives data for the preliminary portion of the period; the second and every alternate horizontal line thereafter gives data for the experimental portion of the period.

VI. DIFFERENCE TABLES. (*a*) TOTALS OF DIFFERENCES; (*b*) PERCENTAGE DIFFERENCES

[Showing differences in experimental feeding between the average of the results of two periods on one ration (the second named in the following tables) and those actually obtained with another ration (the first named in the following tables) in the intervening period.]

(*a*) TOTALS OF DIFFERENCES

Rations	Periods represented	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter: In entire ration: Milk	In entire ration: Total solids	In entire ration: Fat	In experimental feed: Milk	In experimental feed: Total solids	In experimental feed: Fat
		lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
No. 1 to No. 2..........	3	+ 0.7	—10.1	—75.9	+0.11	+0.09	—10.49	—3.59	—16.0	—2.8	—0.74	—31.7	—4.1	—1.4
No. 2 to No. 1..........	3	+16.3	+12.3	+42.2	0	—0.05	+ 7.36	+2.97	+ 6.2	+1.1	+0.43	+11.3	+2.3	+0.8
No. 2 to No. 2..........	5	—20.5	— 4.1	—76.4	—0.71	+0.37	— 7.54	—1.81	—19.6	—2.2	—0.58	—40.4	—3.8	—0.9
No. 1 to No. 3..........	4	— 0.5	—19.9	—46.7	+0.31	—0.06	— 5.20	—2.48	+11.6	—1.4	—0.60	— 1.7	+1.1	—0.2
No. 3 to No. 1..........	4	+12.7	+13.3	—23.3	+0.10	+0.22	— 2.75	—0.03	— 6.6	—1.0	—0.11	—35.1	—4.9	—1.2
No. 3 to No. 3..........	6	+15.0	+ 2.3	—17.4	+0.34	+0.17	— 0.81	—0.05	— 6.9	—0.8	—0.19	— 9.1	—0.4	—0.2
No. 1 to No. 4..........	6	+57.4	+ 3.4	—64.3	+0.68	+0.28	— 5.08	—0.96	—16.9	—1.9	—0.49	—29.0	—1.7	—0.4
No. 4 to No. 1..........	6	—19.4	— 6.9	+35.3	+0.42	+0.15	+ 3.42	+1.15	+ 5.9	+1.0	+0.23	+15.9	+2.5	+0.6
No. 4 to No. 4..........	6	+10.4	— 2.3	—23.3	+0.24	+0.11	— 1.97	—0.41	— 6.6	—0.9	—0.19	—10.8	—0.9	—0.1
No. 1 to No. 5..........	5	+ 2.3	— 1.9	+79.6	—0.09	—0.19	+12.87	+4.43	+15.7	+2.4	+0.84	+51.2	+7.8	+2.6
No. 5 to No. 1..........	4	+22.0	+ 0.8	—96.6	+0.45	+0.28	—13.61	—4.79	—22.0	—3.2	—11.8	—60.7	—8.7	—3.1
No. 5 to No. 5..........	6	— 5.9	— 4.4	—57.4	0	+0.04	— 8.40	—2.77	—10.8	—1.6	—0.51	—33.3	—4.9	—1.6
No. 1 to No. 6..........	5	—41.8	+ 3.8	+65.6	+0.55	+0.20	+12.34	+4.77	+ 6.4	+1.8	+0.56	+36.2	+6.8	+2.4
No. 6 to No. 1..........	4	— 0.5	— 2.9	—72.5	—0.32	—0.18	—11.63	—4.53	—15.3	—2.4	—0.97	—40.9	—6.5	—2.5
No. 1 to No. 1..........	6	+ 2.9	— 1.2	—34.5	+0.49	+0.14	— 2.95	—1.34	— 7.8	—0.9	—0.31	—19.2	—1.7	—0.8
No. 6 to No. 6..........	3	+ 8.6	+ 0.7	—17.3	+0.24	+0.08	— 1.58	—0.49	— 5.1	—0.6	—0.18	—12.1	—1.8	—0.4
No. 1 to No. 1..........	3	+ 5.7	— 1.5	+15.4	+0.29	+0.20	+ 3.62	+1.77	+ 2.0	+0.5	+0.30	+11.0	+2.6	+1.2
No. 1 to No. 7..........	4	— 2.8	— 9.2	—26.4	—0.50	—0.46	— 5.39	—2.75	— 4.9	—1.0	—0.58	— 4.0	—1.7	—1.2
No. 7 to No. 1..........	4	+61.5	+25.5	— 6.1	+0.50	+0.41	+ 0.58	+0.92	—10.1	—1.8	—0.82	—38.0	—4.9	—1.5
No. 1 to No. 1..........	12	— 1.1	— 2.5	+ 5.0	+0.22	+0.09	+ 2.07	+0.68	+ 0.7	+0.1	+0.11	+ 6.9	+1.6	+0.5
No. 7 to No. 7..........	3	+17.2	— 0.4	+ 8.8	+0.16	+0.04	+ 1.76	+0.60	— 0.2	0	+0.01	+ 5.7	+1.1	+0.3
No. 6 to No. 7..........	4	+61.7	+ 9.1	—53.9	—0.87	—0.56	—10.42	—4.18	—19.7	—3.7	—1.34	—43.3	—8.2	—3.8
No. 7 to No. 6..........	5	—13.2	— 1.2	+27.0	+0.89	+0.35	+ 6.76	+1.97	+ 6.6	+1.6	+0.46	+15.0	+4.2	+1.3
No. 6 to No. 6..........	3	— 3.0	+ 0.7	+ 1.4	—0.02	+0.09	+ 0.28	+0.33	+ 0.5	0	+0.07	— 0.1	0	+0.1
No. 7 to No. 7..........	3	+ 5.0	— 0.4	— 8.0	+0.18	+0.06	— 0.46	—0.17	— 2.5	—0.3	—0.09	— 4.5	—0.2	—0.1

(*b*) PERCENTAGE DIFFERENCES

Rations	Periods represented	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter: ration In entire: Milk	Total solids	Fat	In experimental feed: Milk	Total solids	Fat
		lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
No.1 to No.2,	3	0	—2	—6	0	+1	—6	—5	—6	—6	—5	—4	—3	—3
No.2 to No.1,	3	+3	+3	+6	0	0	+5	+5	+4	+5	+4	+3	+3	+2
No.2 to No.2,	5	—1	0	—4	+1	+1	—2	—2	—4	—4	—3	—3	—2	—1
No.1 to No.3,	4	0	—3	—3	+1	—1	—2	—3	—3	—2	—3	+1	+1	0
No.3.to No.1,	4	+1	+2	—1	0	+1	—1	+1	—2	—2	—1	—3	—3	—2
No.3 to No.3,	6	+1	0	—1	0	0	0	0	—1	—1	0	—1	0	0
No.1 to No.4,	6	+2	+1	—1	+1	+1	0	0	—3	—3	—2	—2	—1	—1
No.4 to No.1,	6	—1	—1	0	+1	0	0	0	0	+1	+1	0	+1	+1
No.4 to No.4,	6	0	0	—1	0	0	—1	0	—1	—1	—1	—1	0	0
No.1 to No.5,	5	0	0	+6	0	—1	+6	+5	+6	+5	+5	+6	+5	+5
No.5 to No.1,	4	+1	0	—8	+1	+1	—7	—7	—9	—8	—8	—8	—7	—7
No.5 to No.5,	6	0	0	—3	0	0	—3	—3	—3	—3	—2	—3	—3	—3
No.1 to No.6,	5	—2	0	+4	+1	+1	+5	+5	+1	+2	+2	+3	+4	+4
No.6 to No.1,	4	0	—1	—4	—1	—1	—4	—4	—4	—4	—4	—3	—4	—4
No.1 to No.1,	6	0	0	—2	+1	+1	—1	—1	—2	—2	—2	—2	—1	—1
No.6 to No.6,	3	0	0	—1	0	+1	—1	—1	—2	—2	—1	—1	—1	—1
No.1 to No.1,	3	0	0	+1	+1	+1	+2	+3	+1	+1	+2	+2	+2	+3
No.1 to No.7,	4	0	—2	—1	—1	—2	—2	—3	—1	—2	—4	0	—1	—2
No.7 to No.1,	4	+4	+5	—1	+1	+2	0	+1	—4	—3	—2	—5	—4	—4
No.1 to No.1,	12	0	0	0	0	0	0	0	0	0	0	0	0	0
No 7 to No.7,	3	+1	0	+1	0	0	+1	+2	0	0	0	+1	+2	+1
No.6 to No.7,	4	+3	+2	—3	—2	—2	—4	—5	—6	—8	—8	—4	—6	—6
No.7 to No.6,	5	0	0	+1	+1	+1	+2	+2	+1	+3	+2	+1	+2	+2
No.6 to No.6,	3	0	0	0	0	+1	+1	+1	0	0	+1	0	0	+1
No.7 to No.7,	3	0	0	—1	0	0	0	0	—1	—1	—1	—1	0	0

VII. RESULTS OF EXPERIMENTAL FEEDING ON DIFFERENT RATIONS

RATIONS	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter: In entire ration: Milk	In entire ration: Total solids	In entire ration: Fat	In experimental feed: Milk	In experimental feed: Total solids	In experimental feed: Fat	Ratio of percent of fat to percent of solids-not-fat
	lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
GRAIN FEEDS NOS. 1 AND 2. 138 DAYS ON EACH RATION														
No. 1	2999	977	2285	15.45	5.79	349.66	130.05	75.7	11.6	4.31	233.8	35.8	13.33	1.67
No. 2	2984	954	2166	15.47	5.81	333.81	123.49	72.0	11.0	4.12	226.7	34.7	12.97	1.66
No. 2 ± No. 1	−15	−23	−119	+0.02	+0.02	−15.85	−6.56	−3.7	−0.6	−0.19	− 7.1	−1.1	−0.36	−0.01
% differences	− 1	− 2	− 5	0	0	− 5	−5	−5	−5	−4	− 3	−3	−3	−1
GRAIN FEED NO. 2. 115 DAYS ON EACH RATION														
No. 2 I	2531	784	2089	14.59	5.16	301.38	105.32	82.9	11.9	4.17	268.0	38.6	13.44	1.83
No. 2 II	2554	800	2124	14.71	5.20	308.52	107.47	83.3	12.1	4.21	265.6	38.6	13.46	1.83
II ± I	+23	+16	+35	+0.12	+0.04	+7.14	+2.15	+0.4	+0.2	+0.04	−2.4	0	+0.02	0
% differences	+ 1	+ 2	+ 2	+1	+1	+2	+2	0	+2	+1.	−1	0	0	0
GRAIN FEEDS NOS. 1 AND 3. 207 DAYS ON EACH RATION														
No. 1	4531	1467	3798	14.73	5.19	558.48	196.54	83.9	12.3	4.84	259.0	38.1	13.42	1.84
No. 3	4521	1431	3815	14.74	5.15	562.01	196.24	84.3	12.4	4.83	266.1	39.2	13.70	1.86
No. 3 ± No. 1	−10	−36	+17	+0.01	−0.04	+3.53	−0.30	+0.4	+0.1	−0.01	+7.1	+1.1	+0.28	+0.02
% differences	0	− 2	0	0	−1	+1	0	0	+1	0	+3	+3	+2	+1
GRAIN FEED NO. 3. 138 DAYS ON EACH RATION														
No. 3 I	2949	965	2631	14.78	5.24	388.46	137.43	89.2	13.2	4.67	272.7	40.3	14.28	1.82
No. 3 II	2958	963	2599	14.77	5.26	383.51	135.72	87.9	13.0	4.59	270.3	39.9	14.12	1.81
II ± I	+ 9	−2	−32	−0.01	+0.02	−4.95	−1.71	−1.3	−0.2	−0.08	−2.4	−0.4	−0.16	−0.01
% differences	0	0	− 1	0	0	−1	−1	−1	−2	−2	−1	−1	−1	−1
GRAIN FEEDS NOS. 1 AND 4. 276 DAYS ON EACH RATION														
No. 1	5906	1908	4396	15.31	5.52	658.08	231.30	73.5	11.0	3.87	228.8	34.3	12.08	1.77
No. 4	5983	1918	4297	15.33	5.53	647.58	229.19	71.6	10.8	3.81	225.0	33.9	12.00	1.77
No. 4 ± No. 1	+77	+10	−99	+0.02	+0.01	−10.50	−2.11	−1.9	−0.2	−0.06	−3.8	−0.4	−0.08	0
% differences	+ 1	0	− 2	0.	0	− 2.	−1	−3	−2	−2	−2	−1	−1	0
GRAIN FEED NO. 4. 138 DAYS ON EACH RATION														
No. 4 I	3045	965	2865	14.33	4.92	411.96	141.74	94.2	13.6	4.66	297.0	42.7	14.70	1.91
No. 4 II	3038	968	2809	14.33	4.93	403.67	139.21	92.5	13.3	4.58	290.1	41.7	14.35	1.91
II ± I	− 7	+ 3	−56	0	+0.01	−8.29	−2.53	−1.7	−0.3	−0.08	−6.9	−1.0	−0.35	0
% differences	0	0	− 2	0	0	−2	−2	−2	−2	−2	−2	−2	−2	0

Rations	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter — In entire ration: Milk	Total solids	Fat	In experimental feed: Milk	Total solids	Fat	Ratio of percent of fat to percent of solids-not-fat
	lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
GRAIN FEEDS NOS. 1 AND 5. 207 DAYS ON EACH RATION														
No. 1	4506	1464	2640	15.72	5.98	413.61	155.71	58.5	9.2	3.46	180.8	28.3	10.67	1.65
No. 5	4485	1461	2816	15.66	5.88	439.59	164.77	62.7	9.8	3.68	192.8	30.1	11.30	1.66
No. 5 ± No. 1	−21	−3	+176	−0.06	−0.05	+25.98	+9.06	+4.2	+0.6	+0.22	+12.0	+1.8	+0.63	+0.01
% differences	0	0	+ 7	0	−1	+ 6	+6	+7	+7	+6	+ 7	+6	+6	+1
GRAIN FEED NO. 5. 138 DAYS ON EACH RATION														
No. 5 I	3104	1094	1995	14.55	5.08	290.62	101.67	64.0	9.3	3.26	182.0	26.5	9.23	1.86
No. 5 II	3110	1099	1937	14.60	5.09	283.34	99.02	61.9	9.1	3.16	175.2	25.6	8.93	1.87
II ± I	+6	+5	−58	+0.05	+0.01	−7.28	−2.65	−2.1	−0.2	−0.10	−6.8	−0.9	− .30	+0.01
% differences	0	0	− 3	0	0	−3	−3	−3	−2	−3	−4	−3	−3	+1
GRAIN FEEDS NOS. 1 AND 6. 207 DAYS ON EACH RATION														
No. 1	4321	1454	3860	15.26	5.72	584.71	216.89	88.1	13.4	4.97	264.9	40.2	14.93	1.67
No. 6	4359	1461	3998	15.36	5.76	608.68	226.19	90.5	13.8	5.14	273.5	41.6	15.46	1.67
No. 6 ± No. 1	+38	+7	+138	+0.10	+0.04	+23.97	+9.30	+2.4	+0.4	+0.17	+8.6	+1.4	+0.53	0
% differences	+ 1	0	+ 4	+1	+1	+ 4	+4	+3	+3	+3	+3	+3	+4	0
GRAIN FEED NO. 1. 138 DAYS ON EACH RATION														
No. 1 I	3023	977	2478	14.52	5.05	356.62	121.99	82.0	11.8	4.04	253.7	36.5	12.48	1.88
No. 1 II	3017	977	2405	14.40	5.04	342.87	118.39	79.7	11.4	3.93	246.0	35.1	12.12	1.86
II ± I	−6	0	−73	−0.12	−0.01	−13.75	−3.60	−2.3	−0.4	−0.11	−7.7	−1.4	−0.36	−0.02
% differences	0	0	− 3	−1	0	− 4	−3	−3	−3	−3	−3	−3	−3	−1
GRAIN FEED NO. 6. 69 DAYS ON EACH RATION														
No. 6 I	1533	488	1175	14.58	5.02	171.31	58.89	76.8	11.2	3.85	241.1	35.2	12.10	1.90
No. 6 II	1508	487	1142	14.53	4.99	165.75	56.84	75.8	11.0	3.77	234.4	34.1	11.70	1.91
II ± I	−25	−1	−33	−0.05	−0.03	−5.56	−2.05	−1.0	−0.2	−0.08	−6.7	−1.1	−0.40	+0.01
% differences	− 2	0	− 3	0	−1	−3	−3	−1	−2	−2	−3	−3	−3	+1
GRAIN FEED NO. 1. 69 DAYS ON EACH RATION														
No. 1 I	1470	490	1231	15.28	5.45	188.14	67.00	83.8	12.8	4.56	251.5	38.4	13.70	1.80
No. 1 II	1472	485	1286	15.36	5.50	197.46	70.61	87.4	13.5	4.80	265.1	40.7	14.50	1.80
II ± I	+2	−5	+55	+0.08	+0.05	+9.32	+3.61	+3.6	+0.7	+0.24	+13.6	+2.3	+0.80	0
% differences	0	−1	+ 4	+1	+1	+5	+5	+4	+5	+5	+ 5	+6	+6	0

Rations	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter: In entire ration: Milk	In entire ration: Total solids	In entire ration: Fat	In experimental feed: Milk	In experimental feed: Total solids	In experimental feed: Fat	Ratio of percent of fat to percent of solids-not-fat
	lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
GRAIN FEEDS NOS. 1 AND 7. 207 DAYS ON EACH RATION														
No. 1	4448	1432	3059	15.12	5.58	461.61	169.47	68.6	10.4	3.80	218.4	32.2	11.84	1.71
No. 7	4411	1408	3078	15.04	5.50	461.74	168.32	69.5	10.5	3.81	217.7	32.7	11.94	1.73
No. 7 ± No. 1	−37	−24	+14	−0.08	−0.08	+0.13	−1.15	+0.9	+0.1	+0.01	+4.3	+0.5	+0.10	+0.02
% differences	−1	−2	0	−1	−1	0	−1	+1	+1	0	+2	+2	+1	+1
GRAIN FEED NO. 1. 276 DAYS ON EACH RATION														
No. 1 I	6097	1953	5060	14.84	5.28	747.99	265.04	83.0	12.3	4.34	259.1	38.3	13.57	1.81
No. 1 II	6079	1955	5071	14.88	5.35	755.26	268.78	83.5	12.4	4.42	259.9	38.6	13.76	1.78
II ± I	−18	+2	+11	+0.04	+0.07	+7.27	+3.74	+0.5	+0.1	+0.08	+0.8	+0.3	+0.19	−0.03
% differences	0	0	0	0	+1	+1	+1	+1	+1	+2	0	+1	+1	−2
GRAIN FEED NO. 7. 69 DAYS ON EACH RATION														
No. 7 I	1470	487	828	14.92	5.14	123.54	42.52	56.3	8.5	2.90	170.0	25.4	8.77	1.90
No. 7 II	1495	487	858	14.92	5.12	128.04	43.94	57.5	8.6	2.95	176.2	26.3	9.00	1.91
II ± I	+25	9	+30	0	−0.02	+4.50	+1.42	+1.2	+0.1	+0.05	+6.2	+0.9	+0.23	+0.01
% differences	+ 2	0	+ 4	0	0	+4	+3	+2	+1	+2	+4	+4	+3	+1
GRAIN FEEDS NOS. 6 AND 7. 207 DAYS ON EACH RATION														
No. 6	4422	1442	3670	14.72	5.21	530.57	183.51	82.6	12.0	4.14	253.9	36.8	12.74	1.83
No. 7	4497	1452	3589	14.53	5.11	513.39	177.36	79.7	11.4	3.94	247.4	35.4	12.24	1.84
No. 7 ± No. 6	+75	+10	−81	−0.19	−0.10	−17.18	−6.15	−2.9	−0.6	−0.20	−6.5	−1.4	−0.50	+0.01
% differences	+ 2	+ 1	− 2	−1	−2	− 3	−3	−4	−5	−5	−3	−4	−4	+1
GRAIN FEED NO. 6. 69 DAYS ON EACH RATION														
No. 6 I	1392	482	642	14.88	5.61	95.32	35.95	46.3	6.9	2.59	133.5	19.9	7.47	1.65
No. 6 II	1384	484	632	14.91	5.58	93.90	35.24	45.9	6.8	2.56	130.7	19.4	7.30	1.67
II ± I	−8	+2	−10	+0.03	−0.03	−1.42	−0.71	−0.4	−0.1	−0.03	−2.8	−0.5	−1.7	+0.02
% differences	−1	0	− 2	0	−1	−1	−2	−1	−1	−1	−2	−3	−2	+1
GRAIN FEED NO. 7. 69 DAYS ON EACH RATION														
No. 7 I	1490	487	1171	15.67	5.76	183.39	67.34	78.6	12.3	4.52	240.5	37.7	13.87	1.72
No. 7 II	1473	487	1179	15.81	5.82	186.29	68.57	80.1	12.7	4.66	242.0	38.2	14.10	1.72
II ± I	−17	0	+8	+0.14	+0.06	+2.90	+1.23	+1.5	+0.4	+0.14	+1.5	+0.5	+0.23	0
% differences	− 1	0	+1	+1	+1	+2	+2	+2	+3	+3	+1	+1	+2	0

NOTE EXPLANATORY OF VI "DIFFERENCE TABLES," (PAGES 455-456), AND VII "RESULTS OF EXPERIMENTAL FEEDING," (PAGES 457-459)

Although "difference tables" have been printed in the last nine reports, accompanied by full explanations of their meaning, they are so condensed from the data of Table V that explanatory notes are always in order.

When a cow eats a certain ration during a feeding period, another during a second period, returning to the first ration for a third period, all three being of equal lengths, and, so far as may be, all other things being equal, it is fair to assume, and in the discussion of feeding experiments it is usually assumed, that the average of the results obtained during the first and third periods on the ration then fed is what would have been secured during the second period had the feeding continued on one ration. A comparison of this average with the results actually obtained with another ration serves to show the relative value of the different fodders and feeds. The *difference between these calculated averages and the actual results* form the "differences" which measure the relative values of the two rations.

The first comparison of the record of the cow Elizabeth (page 444) is given in full to show more clearly just what is meant by the figures in the "difference tables.'

Record of ELIZABETH for the experimental portions of periods I, II and III	Total dry matter eaten	Dry matter eaten in experimental feed	Milk	Total solids	Fat	Total solids	Fat	Weight of products obtained per 100 lbs. of dry matter: In entire ration: Milk	Total solids	Fat	In experimental feed: Milk	Total solids	Fat
	lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Average of actual record for periods I and III (No. 1 ration)	494.4	163.0	384.6	15.69	5.84	60.09	22.24	78.1	12.2	4.51	236.1	36.9	13.7
Actual record for period II (No. 2 ration) ..	485.9	157.5	354.7	16.00	6.00	57.76	21.27	73.0	11.7	4.38	225.2	36.0	13.5
Record made upon No. 2 ration ± the average of those made on No. 1 ration................	−8.5	−5.5	−29.9	+0.31	+0.16	−33.3	−0.97	−5.1	−0.5	−0.13	−10.9	−0.9	−0.2

The first horizontal line of figures shows the average of the records of dry matter eaten, and of milk, solids and fat given, etc., obtained in the experimental portions of the first and third feeding periods, while the cow was eating the No. 1 ration (page 444). The second horizontal line of figures shows the actual records of dry matter, milk, etc., obtained during the experimental portion of the second period, when she ate the No. 2 ration (page 444). The third horizontal line shows the amounts, greater or less as the case may be, of dry matter eaten, milk given, etc., when No. 2 ration was fed as compared with the average of the records on the No. 1 ration. These differences furnish a measure of the relative value of the two rations, it being assumed, as stated above, that the averages correctly indicate the consumption and production

which would have occurred during the intervening period had the ration remained unchanged.

The figures in the third horizontal line in the above table, together with two other sets similarly obtained by comparing Elizabeth's period III and V with IV and Inez's period II and IV with III added, each column by itself, gave the first horizontal line in table (*a*) "totals of differences," (page 455) beginning 3 +0.7 —10.1 —75.9 +0.11. The figures in table (*b*) "percentage differences" —which are the final results and measures of the relative worth of the various rations—are obtained by dividing the "total differences" by the total actual consumption (of dry matter) or production (of milk, solids, fat and the same proportionate to 100 pounds of dry matter eaten). Thus, for example, the calculated amount of milk given when the No 1 ration was fed to the cows mentioned above in the periods coupled (Elizabeth I and III, III and V, Inez II and IV) was 1244.6 pounds. This is 75.9 pounds more than the amount actually yielded when No. 2 ration was fed (1168.7). Division furnishes the percentage differences: 75.9 ÷ 1244.6, × 100 = 6. The "percentage difference" is +6 or, in other words, the cows when fed on the medium ration during the intermediate periods yielded 6 percent more milk than presumably they would have had they continued on the No. 1 ration at precisely the same time they did eat the No. 2. This figure (+6) is the third in the first horizontal line in table (*b*) "percentage differences," (page 456). Similar comparisons with the remaining items show the percent of excess or deficit of consumption or product resulting from the use of the two rations.

The outcome is also shown in a somewhat different manner in Table VII, "Results of Experimental Feeding on Different Rations," wherein the total products for each period and for each calculated period are added. Thus, for example, in the case of the cows above mentioned, each fed five periods, including 10 twenty-three-day experimental portions, a comparison of 138 days' feeding for one cow on each ration may be made and neither side of the comparison suffer from the effects of advancing lactation, this being equalized. The use of the data found in Table V, "Production Records," with the cows in question for the experimental portion of the periods stated below will give the equivalent of 138 days' feeding on one ration.

Elizabeth III, Inez II and IV (on No. 1 ration).................... 69 days
Elizabeth I and III, III and V, Inez II and IV (means in each case) records assumed as a result of calculation which they would have made in the respective intermediate periods had they been fed the No. 1 ration.............................. 69 days

Total .... 138 days

And, similarly, the following aggregation furnished equivalent data for the other ration (No. 2):

Elizabeth II and IV, Inez III (on No. 2 ration).................. 69 days
Elizabeth II and IV, Inez III and V, Hallowe'en I and III (means in each case) the records assumed, etc., etc.................. 69 days

Total .... 138 days

This permits the calculation of the consumption and production of each cow on each ration for the self same days of the experimental portion of the periods other than the first and last used with each cow, thus affording an excellent and, usually, accurate measure of the relative worth of the two ra-

tions. The result of this comparison forms the table at the top of page 457, the No. 1 ration figures beginning 2999, 977, 2285, and the No. 2 ration data 2984, 954, 2166. The average percentages of total solids and fat are obtained by addition and not by cross division. This gives to each cow the same influence upon the final results instead of giving greatest preponderance to those yielding most largely of milk, solids and fat, and less to those giving smaller amounts.

It should be remarked, however, that as a matter of fact exact equality cannot always be obtained by the method of calculation last referred to. When a cow maintains her milk flow fairly well, little or no trouble is encountered. When, however, considerable shrinkage occurs, the side of the comparison which includes the record of the first period has, as a rule, the advantage. In other words, the figures derived from the means of the results of periods I and III, and III and V, and from the actual records of periods III and V, may have an advantage over those obtained from the means of the results of periods II and IV, and from the actual records of periods II and IV. This is due to the fact that the records of the first period, in which, often, the heaviest milk flow is given, helps on the one side of the comparison and not on the other. To be sure, this side has also to carry the records of the last period, wherein, frequently, the smallest flow is given. Sometimes, but not always, these two tend to counterbalance. If the shrinkage is large in the last period, it is usually but not always thrown out of the experiment. The first period is seldom thus excluded, however; hence occasionally this condition is met.

INDEX